MODEL 427A

VOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

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OPERATING AND SERVICE MANUAL

-hp- Part No. 00427-90000

MODEL 427A

VOLTMETER

Serial Prefixed: 550-

Hewlett-Packard Company
P. O. Box 301, Loveland, Colorado, 80537 U. S. A.

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MULTI-FUNCTION METER

model
427A

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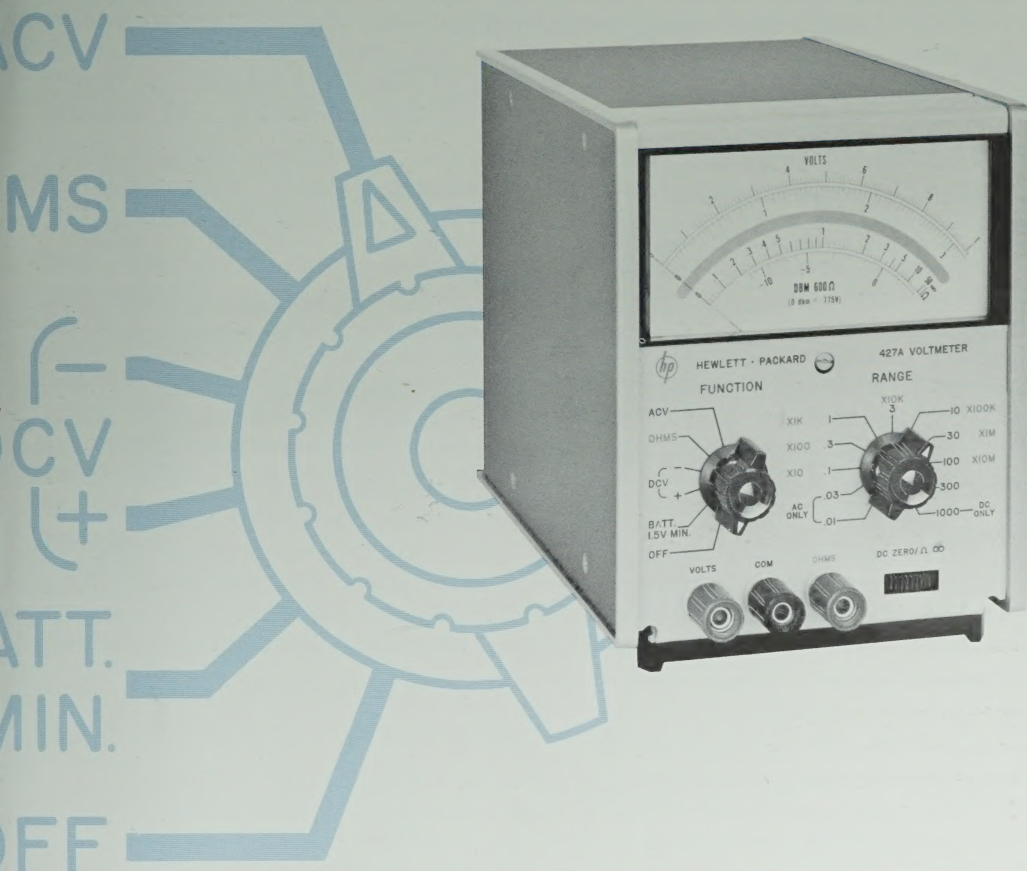


FEATURES

Multiple function
Ten ranges of AC voltage measurements
Nine ranges of DC voltage measurements
Seven ranges of ohms measurements
10 megohm input impedance
Floating input
All solid state
Battery operation
AC line and battery operation with option: 01
Taut band meter individually calibrated

P. O. Box 301, Loveland, Colorado, 80537, Tel. (303) 667-5000
Europe: 54 Route Des Acacias, Geneva, Switzerland, Cable: "HEWPACKSA" Tel. (022) 42.81.50

DESCRIPTION

The new all solid state Hewlett-Packard 427A Voltmeter offers a broad measuring capability at moderate cost. This instrument measures: DC voltages from 100 mv full scale to 1 kv full scale, AC voltages from 10 mv full scale to 300 v full scale, and resistance from 10 ohms center scale to 10 megohms center scale. A dbm scale is included and is calibrated so that 0 dbm is 1 mw into 600 ohms.

This versatile ℎ𝑝 427A will be valuable in any laboratory, production line, service department, or in the field. Operation is from one internal battery, a 22-1/2 volt dry cell, which provides more than 300 continuous hours of typical operation. AC line and battery operation is available as an option.

Low zero drift and maintenance of calibration of the circuit are retained when making measurements so that only an occasional adjustment of the zero control is needed.

SPECIFICATIONS

DC VOLTMETER

Voltage Ranges: ±100 mv to ±1000 v full scale in a 1, 3, 10 sequence (9 ranges).

Accuracy: ±2% of full scale on any range (0°C to 50°C).

Input Resistance: 10 megohms on all ranges.

AC Rejection: Superimposed peak AC voltages 100 times greater than full scale affect reading less than 1% for 60 cps and above. 450 volts peak maximum.

Overload: 1200 vdc on any range.

AC VOLTMETER

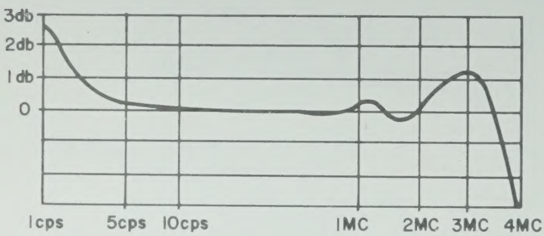
Voltage Ranges: 10 mv to 300 v rms full scale in a 1, 3, 10 sequence (10 ranges).

Frequency Range: 10 cps to 1 MC.

Accuracy: (0°C to 50°C).

Range	±2% of full scale
.01 V-30 V	10 cps-1 MC
100 V-300 V	10 cps-100 KC

Frequency Response:



Typical frequency response 10 mv to 30v ranges.

Input Impedance: 10 megohms shunted by 40 pf on 10 mv to 1 v ranges; 20 pf on 3 v to 300 v ranges.

Response: Responds to the average value of the input; calibrated in rms volts for a sine wave input.

Overload: 300 v/rms momentarily up to 1 v range. 425 v/rms maximum above 1 v range.

OHMMETER

Resistance Ranges: 10 ohms center scale to 10 megohms center scale (7 ranges).

Accuracy: ±5% of reading at midscale (0°C to +50°C).

Source Current:

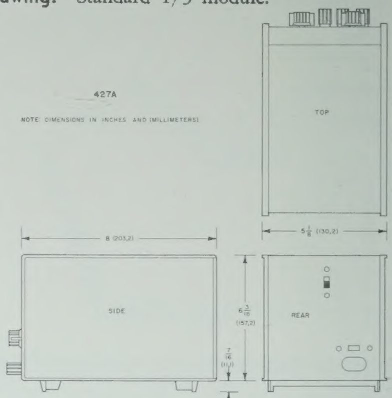
Range	Open Circuit Voltage	Short Circuit Current
X 10	.1 V	10 ma
X 100	.1 V.	1 ma
X 1 K	1 V	1 ma
X 10 K	1 V	100 μA
X 100 K	1 V	10 μA
X 1 M	1 V	1 μA
X 10 M	1 V	0.1 μA

GENERAL

Floating Input: May be operated up to 500 vdc above ground. (Ohms input open in any function except ohms—volts input open when instrument is in off position).

Power: 22-1/2 volt dry cell battery. (Eveready No. 763 or RCA VS102).
Option 01: Battery operation and AC line operation (selecteable on rear panel). 115 or 230v ±20%, 50 cps to 1000 cps, 1/2 w.

Outline Drawing: Standard 1/3 module.



Weight: Net, 5-1/4 lbs. (2,36 kg); Shipping, 6-1/2 lbs (2,9 kg).

Accessories Available:
11039A Capacitive voltage divider (1000:1) 25 kv max.
11001A 45" test lead, dual banana plug to male BNC.
11002A 5' test lead, dual banana plug to alligator clips.
11003A 5' test lead, dual banana plug to pencil probe and alligator clip.
10111A BNC female-to-banana-plug adapter.

Price: ℎ𝑝 427A: $195.00 with battery.
Option 01: AC line and battery operation $230.00

Prices f.o.b. factory
Data Subject to change without notice
► Indicates change from prior specifications

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 427A is a versatile, compact, self-contained voltmeter. It is capable of making dc measurements from 1 mv to 1000 volts, ac measurements from 0.3 mv to 300 volts at frequencies from 10 Hz (cps) to 1 MHz (Mc), and resistance measurements from 0.2 ohms to 500 megohms. With the 01 option, the Model 427A may be powered either by the 115 or 230 volt line or by an internal 22-1/2 volt dry cell battery.

1-3. The use of solid state components throughout gives the 427A both ruggedness and reliability. Current drain from the battery is very low, and typical battery life is about 300 hours.

1-4. The specifications and a full description of the Model 427A are given in the enclosed data sheet.

1-5. INSTRUMENT AND MANUAL IDENTIFICATION.

1-6. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 427A described in this manual.

1-7. If the first three digits of the serial number are prefixed with an E or a G, your instrument was produced in Europe. An E000-00000 serial number indicates that the instrument was manufactured in England; a G000-00000 serial number indicates that the instrument was manufactured in Germany.

1-8. AVAILABLE ACCESSORIES.

1-9. The following accessories are available for the Model 427A:

-hp- 11001A 45" test lead - dual banana to bnc male
-hp- 11002A 5' test lead - dual banana to alligator clips
-hp- 11003A 5' test lead - dual banana to pencil probe and alligator clip
-hp- 10111A shielded bnc female to banana plug adaptor
-hp- 11039A 1000:1 capacitive voltage divider

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 427A Voltmeter. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5 . If there is damage or deficiency, see the warranty on the inside rear cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 427A uses a 22.5 volt dry cell battery for its primary power source. However, if Option 01 is included, the Model 427A can be operated from any source of 115 or 230 volts (±10%) at 50 to 1000 Hz (cps). With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until the desired line voltage appears. Power dissipation is less than 1 watt maximum.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Option 01 427A is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 427A is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds +55°C (140°F).

2-12. BENCH MOUNTING.

2-13. The Model 427A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 427A may be rack mounted by using an Adapter Frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your local -hp- Sales and Service Office. (See Appendix B for office locations.)

2-16. COMBINATION MOUNTING.

2-17. The Model 427A may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 11051A). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit itself, it can be bench or rack mounted and is analogous to any full-module instrument.

2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

> If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-20. If original container is to be used, proceed as follows:

a. Place instrument in original container if available. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

2-21. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT," "FRAGILE" etc.

SECTION III

OPERATING INSTRUCTIONS

NOTE

In this manual, the international standard unit of frequency, the Hertz, will be used rather than cycles per second.

1 Hertz (Hz) = 1 cycle per second

3-1. INTRODUCTION.

3-2. The Model 427A may be operated as a dc voltmeter, ac voltmeter, ohmmeter or db meter. This section contains operating instructions for each mode of operation.

3-3. FRONT AND REAR PANEL DESCRIPTION.

3-4. Figure 3-1 shows the location of all the Model 427A controls and indicators and explains the function of each. The rear panel is shown with Option 01. The standard rear panel is blank.

3-5. OPERATING INSTRUCTIONS.

3-6. MECHANICAL ZERO ADJUSTMENT.

3-7. Before any measurements are made, complete the Mechanical Zero Adjustment in the following steps.

a. Be sure instrument has been off for at least one minute.

b. Rotate Mechanical Zero Adjustment screw CLOCKWISE until meter pointer is to the left of zero and moving upscale toward zero.

c. Continue to rotate adjustment screw clockwise. STOP when needle is exactly on zero. If needle overshoots, repeat step b.

d. When pointer is exactly over zero, rotate adjustment screw slightly COUNTERCLOCKWISE to relieve tension on suspension. If the pointer moves to the left, repeat whole procedure, but make the counterclockwise rotation less.

3-8. TURN-ON PROCEDURE.

3-9. Standard Instrument.

a. Rotate the FUNCTION Switch to the BATT/1.5 MIN position.

b. The meter should read 1.5 or higher on the 0-3 scale, indicating that the battery voltage is 15 volts or higher. If the reading is below 1.5, replace the battery according to the steps in Paragraph 5-13.

3-10. Option 01 Instrument.

a. Select either battery or line operation with the rear panel BATT/LINE slide switch. If battery operation is selected, check the battery according to Paragraph 3-9.

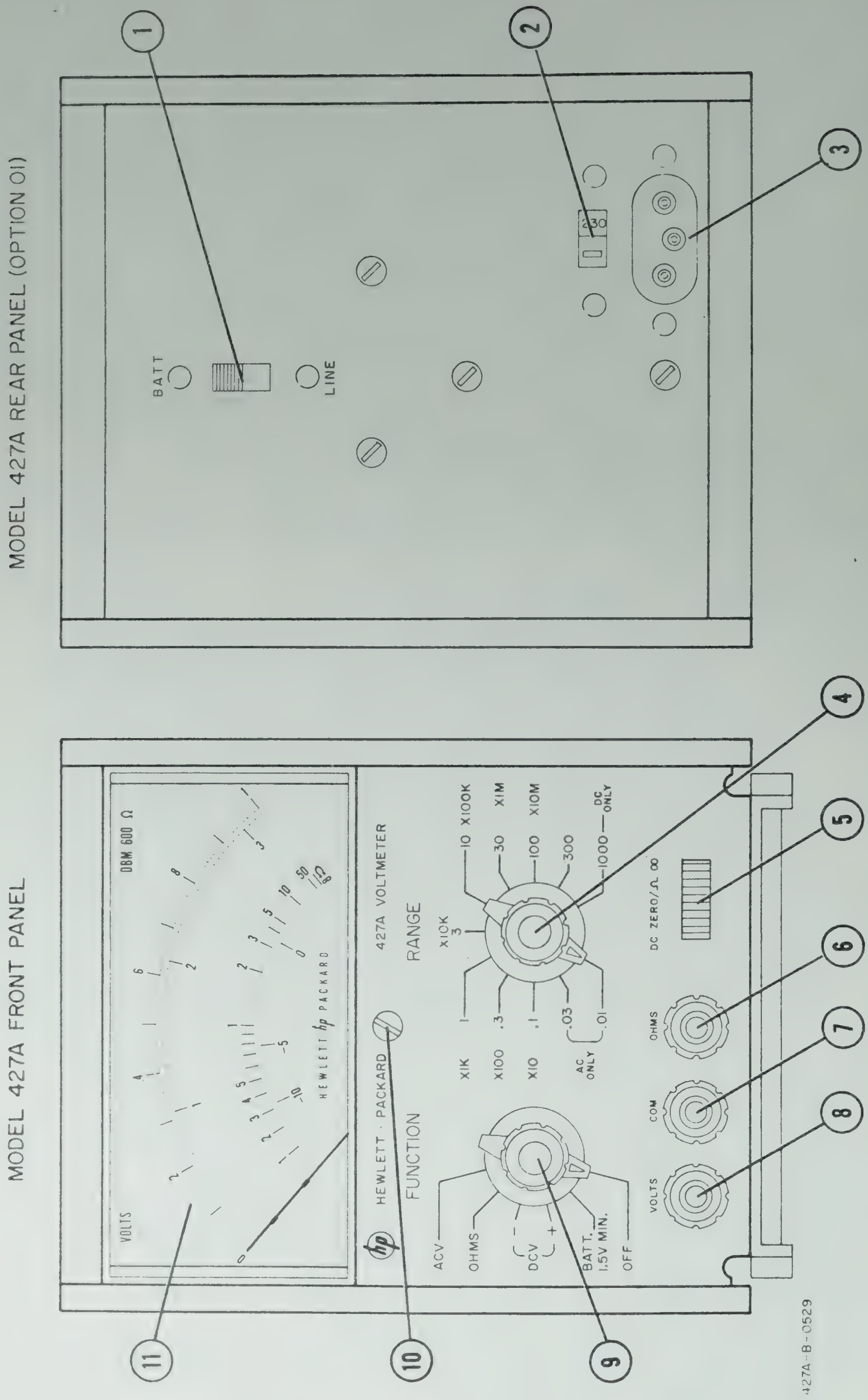


Figure 3-1. Front and Rear Panel Description

(1) BATT/LINE (option 01 only) slide switch: Selects either battery or line operation.

(2) 115/230 slide switch (option 01 only): Selects either 115 vac or 230 vac for line operation.

(3) Line input (option 01 only): Connects AC line current to instrument.

(4) RANGE switch: Selects appropriate range of unknown input.

(5) DC ZERO/Ω ∞ thumbwheel: Used to electrically zero the instrument in DC mode and to infinity-set the instrument in OHMS mode.

(6) OHMS terminal: Connects unknown resistance to instrument.

(7) COM terminal: Connects to instrument common.

(8) VOLTS terminal: Applies unknown ac or dc voltage to instrument.

(9) FUNCTION switch: Selects mode of operation. Selections are OFF, BATT, +DC, -DC, OHMS and AC.

(10) Mechanical zero: Mechanically zeroes the indicator.

(11) Meter face: Displays the magnitude of unknown resistance or voltage in ohms or volts respectively.

Figure 3-1. Front and Rear Panel Description (Cont'd)

b. If line operation is selected, set the 115/230 slide switch to indicate the line voltage used. Rotate the FUNCTION switch to the desired function. During line operation, the BATT/1.5 MIN check position displays the output of the Option 01 power supply. The reading should be 1.5 or higher on the 0-3 scale, indicating a power supply output of 15 volts or more. This serves as a convenient check of the power supply.

3-11. DC MEASUREMENTS.

a. Rotate the FUNCTION switch to +DCV or -DCV depending on the polarity of the input.

b. Short the VOLTS input to the COM input, rotate RANGE to 0.1, and adjust the DC ZERO/Ω∞ thumbwheel for zero meter deflection.

c. Remove shorting connection. If there is a zero offset with COM and VOLTS open, refer to the Alignment Procedures in Paragraph 5-30.

d. Select approximate range of input with RANGE switch.

CAUTION

DO NOT APPLY MORE THAN 1200 VDC TO ANY DC RANGE.

e. Connect input across VOLTS and COM terminals and read magnitude of input on meter.

3-12. RESISTANCE MEASUREMENTS.

a. Rotate the FUNCTION switch to OHMS.

b. Select the approximate range with the RANGE switch; and with the input terminals open, adjust the DC ZERO/Ω∞ thumbwheel for an ∞ indication on the ohms scale. (Pointer should rest on the mark just to the left of ∞.

c. Connect the unknown resistance across the OHMS and COM terminals. Read the resistance value on the ohms range.

NOTE

For best accuracy, select an ohms range that will place the meter pointer near the center of the scale.

3-13. AC MEASUREMENTS.

3-14. The Model 427A responds to the average value of the ac input and is calibrated in rms volts for a sine wave input. Since the average value and the rms value of a non-sinusoidal signal are different, any distortion on the input will affect the accuracy of the reading. Table 3-1 shows the effect of harmonic distortion on a reading.

3-15. Use the following steps to make an ac measurement.

a. Rotate FUNCTION switch to ACV.

b. Rotate RANGE switch to approximate range of input voltage.

CAUTION

DO NOT APPLY MORE THAN 425 V RMS WHEN THE INSTRUMENT IS ON RANGES ABOVE 3, OR MORE THAN 300 V RMS ON RANGES BELOW 3.

c. Connect the signal to be measured to the VOLTS and COM terminals and read the magnitude on the voltage scale.

Table 3-1. Effects of Harmonic Distortion

INPUT VOLTAGE CHARACTERISTICS	TRUE RMS VALUE	METER INDICATION
Fundamental = 100	100	100
Fundamental + 10% second harmonic	100.5	100
Fundamental + 20% second harmonic	102	100 - 102
Fundamental + 50% second harmonic	112	100 - 110
Fundamental + 10% third harmonic	100.5	96 - 104
Fundamental + 20% third harmonic	102	94 - 108
Fundamental + 50% third harmonic	112	90 - 116

NOTE

This chart is universal in application since these errors are inherent in all average-responding voltmeters. The error shown above may vary with the phase relationship between the harmonic and fundamental.

3-16. DB MEASUREMENTS.

a. Making a db or dbm measurement is essentially the same as making an ac voltage measurement. Follow the steps in Paragraph 3-13, but read the magnitude on the db scale.

b. The 1 volt position of the RANGE switch is the 0 dbm range. Each position above 1 volt is a 10 db increase, and each position below 1 volt is a 10 db decrease. Table 3-2 lists the db value of each range.

Table 3-2. DB Range Identification

RANGE	DB	RANGE	DB
300	+50	1	0
100	+40	0.3	-10
30	+30	0.1	-20
10	+20	0.03	-30
3	+10	0.01	-40

c. A given db reading is equal to the algebraic sum of the scale and the meter reading. For example, if the meter reading were -6 and the instrument were on the 10 volt (+20 db) range, the final reading would be 20 db -6 db = 14 db.

d. The 427A meter is calibrated in dbm. 0 dbm is equivalent to 0.775 volt dropped across a 600 Ω load. Consequently, any dbm measurements must be made across a total impedance of 600 Ω. Measurements across other impedances will be in db, but not dbm.

e. To convert a db reading to dbm, use the Impedance Correction Graph (Figure 3-2). For example: To convert a +30 db reading made across 50 Ω to dbm, locate the 50 Ω load impedance on the bottom of the graph. Follow the impedance line to the heavy black line and read the meter correction at that point. The correction for 50 Ω is +10.5 dbm, and the corrected reading is +40.5 dbm.

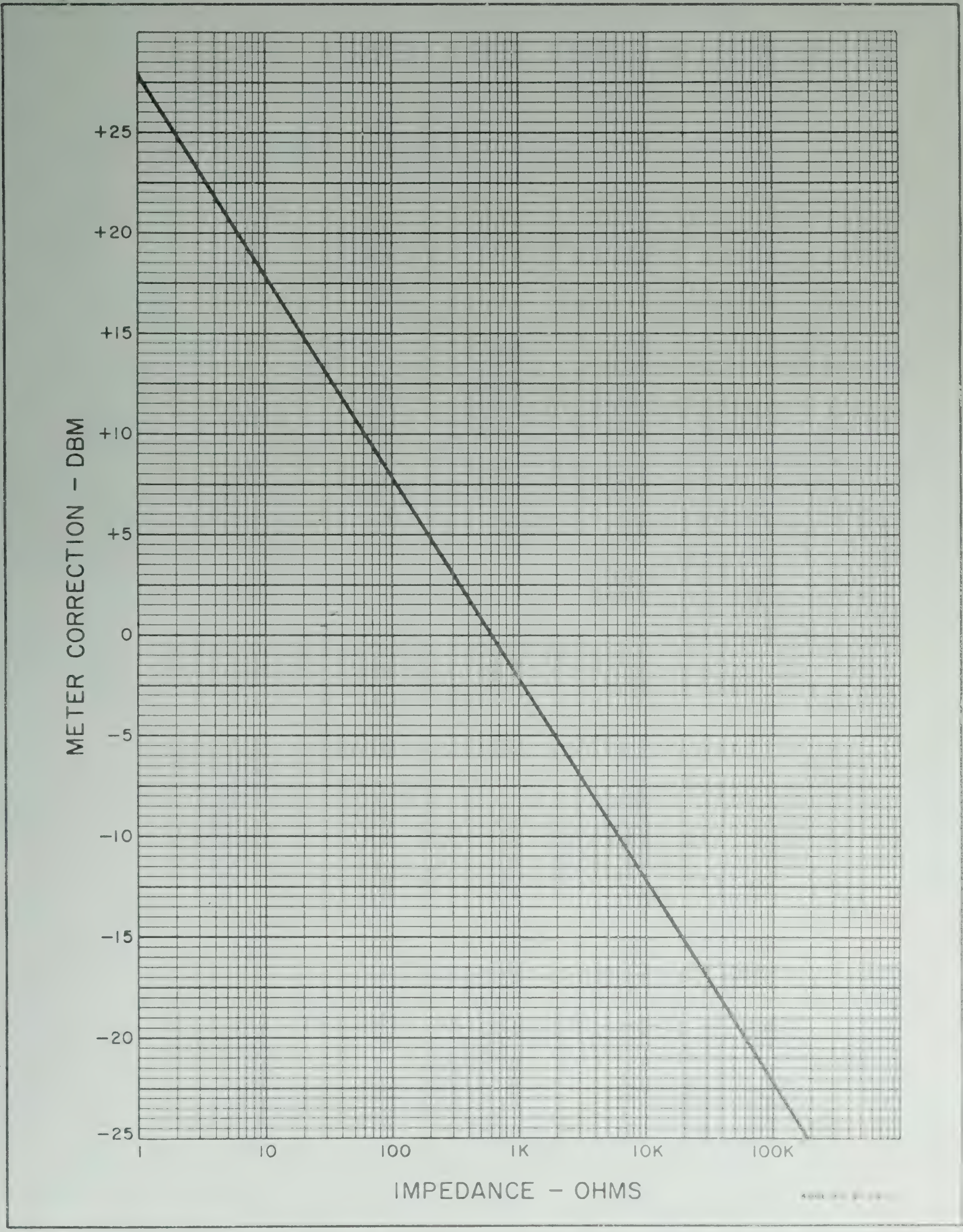


Figure 3-2. Impedance Correction Graph

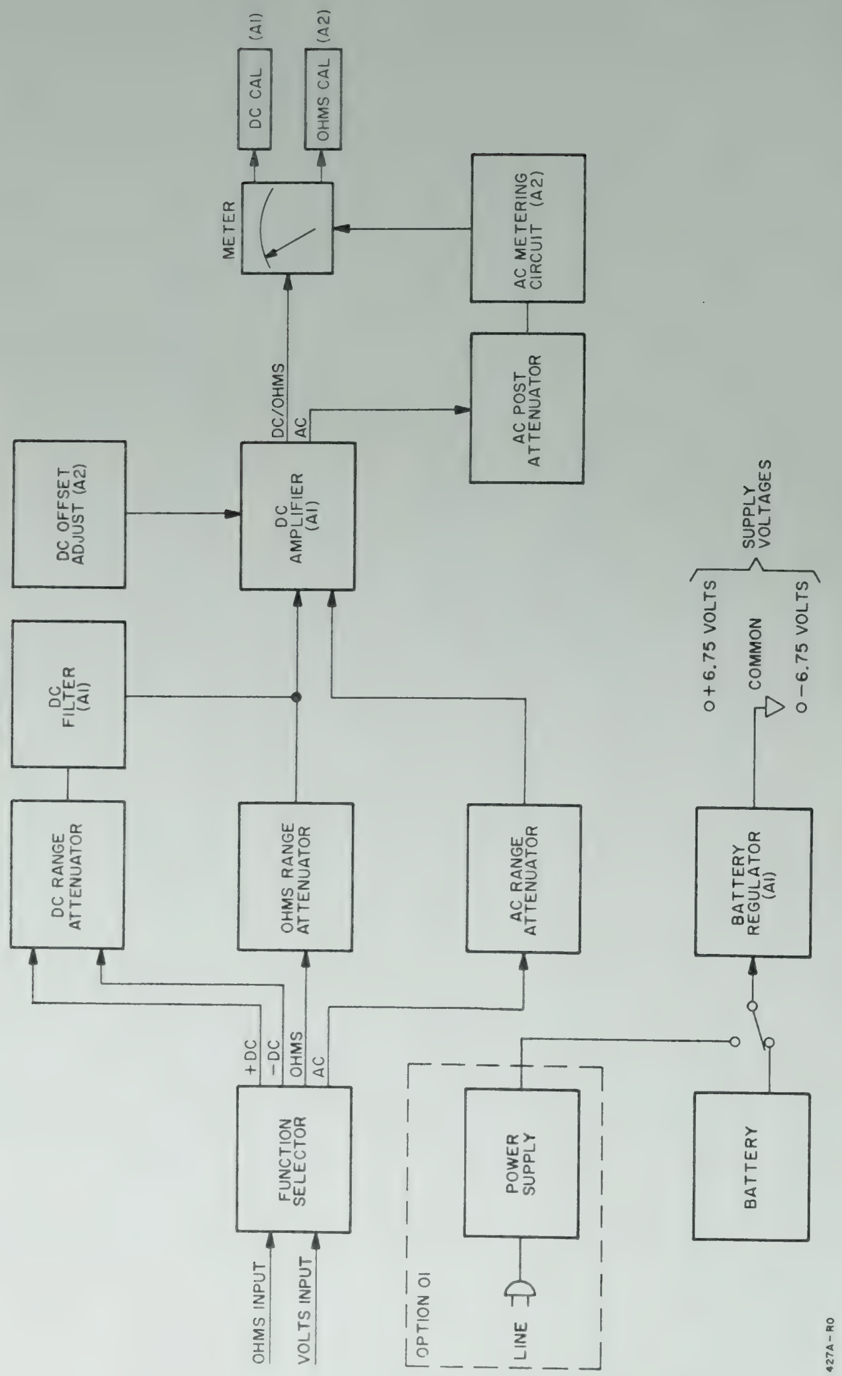


Figure 4-1. Simplified Block Diagram

SECTION IV

THEORY OF OPERATION

NOTE

In this manual, the international standard unit of frequency, the Hertz, will be used rather than cycles per second.

1 Hertz (Hz) = 1 cycle per second

4-1. GENERAL.

4-2. The Model 427A measures ac voltage, dc voltage, and resistance. It is battery operated, but with Option 01, can be powered by line voltage. Figure 4-1 shows a simplified block diagram of the 427A.

4-3. The Battery Regulator (A1) regulates the battery output and provides +6.7 and -6.7 volt bias supply to the amplifiers. The 427A uses two amplifiers, the DC Amplifier (A1) and the AC Metering Circuit (A2). The former is a high input impedance unity gain amplifier used to amplify dc and resistance inputs. It also serves as a preamplifier for ac signals. The AC Metering Circuit amplifies ac signals from the preamplifier, converts them to dc signals proportional to the average ac, and feeds them to the meter. The meter displays the rms value of the ac.

4-4. The DC Offset Adjust (A2) compensates for leakage current from the dc amplifier, and the DC and OHMS CAL are resistive circuits used for calibration.

4-5. DC OPERATION.

4-6. Figure 4-2 shows the Model 427A in the DC Mode of Operation. The dc input is first applied to the DC Range Attenuator where it is attenuated by 10 db for each step of the attenuator. Dc current from the attenuator goes to the DC Filter, and the filter rejects any ac superimposed noise that may be present on the input. The dc output of the filter goes to the DC Amplifier (A1) and then to the meter. The DC Amplifier matches the high impedance of the attenuator to the low impedance of the meter. The DC CAL circuits are resistive circuits in series with the meter used to adjust the meter current to calibrate the lower ranges.

4-7. OHMS OPERATION.

4-8. Figure 4-3 is a block diagram of the Model 427A in the OHMS mode of operation. With the input open, R_a and R_b form a voltage divider. The voltage across R_b causes full scale current to flow through the meter. The Ohms Cal circuit adjusts the meter current for an indication of ∞ with the input open. When R_x is equal to R_b, the total resistance from the OHMS terminal to ground will be $R_b/2$, the voltage across R_b and R_x will be halved, and the meter indication will be half scale. The Model 427A is designed so that the full RANGE setting will be displayed in the center of the scale. For example, 10 Ω on the X10 range is a center scale reading.

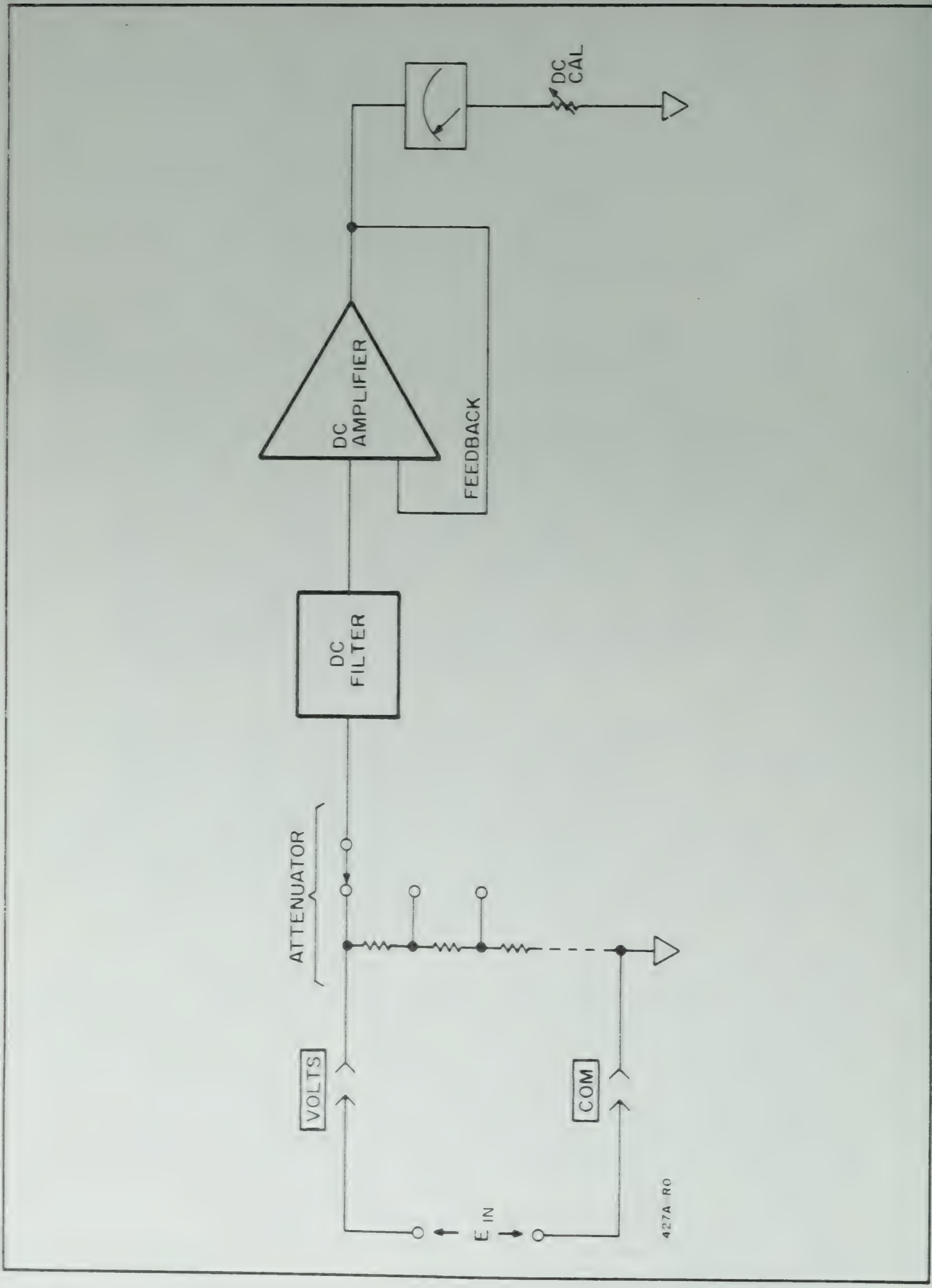


Figure 4-2. DC Operation

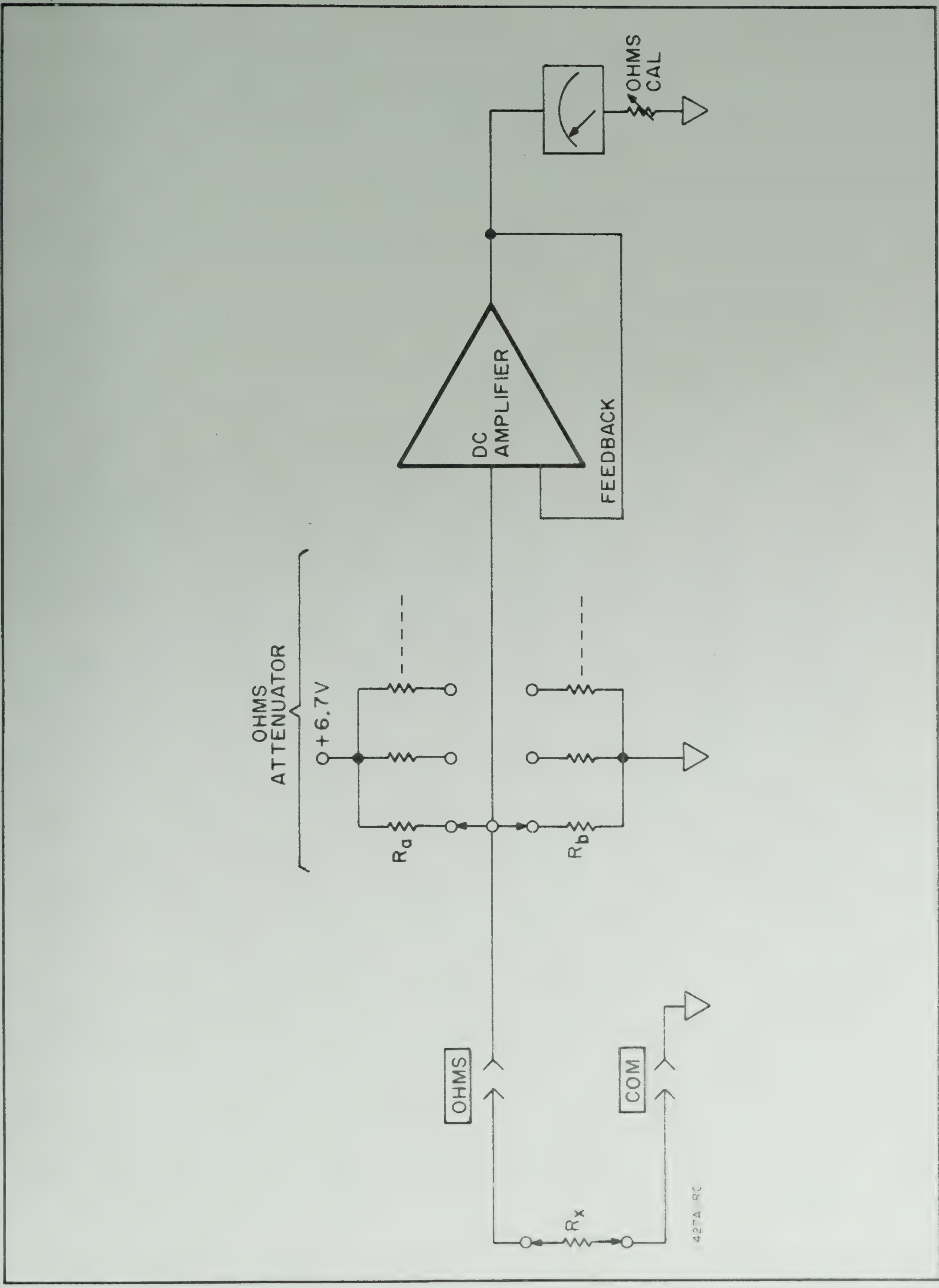


Figure 4-3. Ohms Operation

4-9. AC OPERATION.

4-10. Figure 4-4 shows a block diagram of the 427A in the ac mode of operation. The input signal goes to the AC Range Attenuator. On the 1 volt range and below the signal is not affected by the ac range attenuator; but on all the higher ranges, the signal is attenuated by 50 db. Capacitor C3 adjusts the frequency response of the attenuator with a 3 volt 100 KHz input. The signal from the AC Range Attenuator goes through the DC Amplifier to the AC Post Attenuator where it is attenuated by 10 db for each step of the RANGE selector. The DC Amplifier matches the low impedance of the Post Attenuator to the high impedance of the Range Attenuator, acting as a preamplifier.

4-11. The ac metering circuit contains both a feedback stabilized ac amplifier and an averaging meter circuit. The meter circuit converts the ac signal to a dc voltage proportional to the average of the ac amplifier output. R_c adjusts the current through the meter so that the scale reading is in rms volts.

4-12. CIRCUIT DESCRIPTIONS.

4-13. DC AMPLIFIER (A1).

4-14. Figure 6-3 is the schematic diagram of the Model 427A. The input to the DC Amplifier (A1) is applied through Pin 2 to the impedance converter A1Q6. A field-effect transistor is used as the impedance converter because of its characteristically high input impedance. Transistors A1Q7 and A1Q9 make up a two-stage amplifier, with A1Q9 as an emitter follower output stage. The signal from the emitter of A1Q8 is fed back to the base of A1Q7 for gain stabilization.

4-15. A1Q8 acts as a constant current source to A1Q6. This constant current in A1Q6 assures linear tracking and helps minimize drift.

4-16. DC OFFSET (A2).

4-17. The gate leakage from A1Q6 (I_{GSS}) amounts to a fraction of a nanoamp. This current is insignificant by itself, but with the input open it flows through the DC Range Attenuator resistance of 10 megohms and the resultant voltage drop causes a few millivolts deflection on the lower dc scales. When measuring across a low impedance, I_{GSS} flows mostly through the low impedance, and its effect on the reading is insignificant. However, when measuring across a high impedance, I_{GSS} has a greater effect. At elevated temperatures, I_{GSS} becomes much larger, and could create a larger error.

4-18. The DC Offset Circuit (A2) (see Figure 4-5) compensates for the leakage from A1Q6. A positive voltage tapped from A2R17 reverse biases A2CR1. The reverse leakage current from A2CR1 (I_R) meets an extremely high resistance at the gate of A1Q6 and passes through the much lower resistance of the attenuator, in a direction opposite to that of I_{GSS}. By adjusting A2R7, I_R can be set so that it and I_{GSS} cancel each other. The net voltage drop across the attenuator would then be zero. A2CR1 has a temperature characteristic quite similar to that of A1Q6. Therefore, as I_{GSS} increases, I_R increases and the amount of additional error at higher temperatures is lessened.

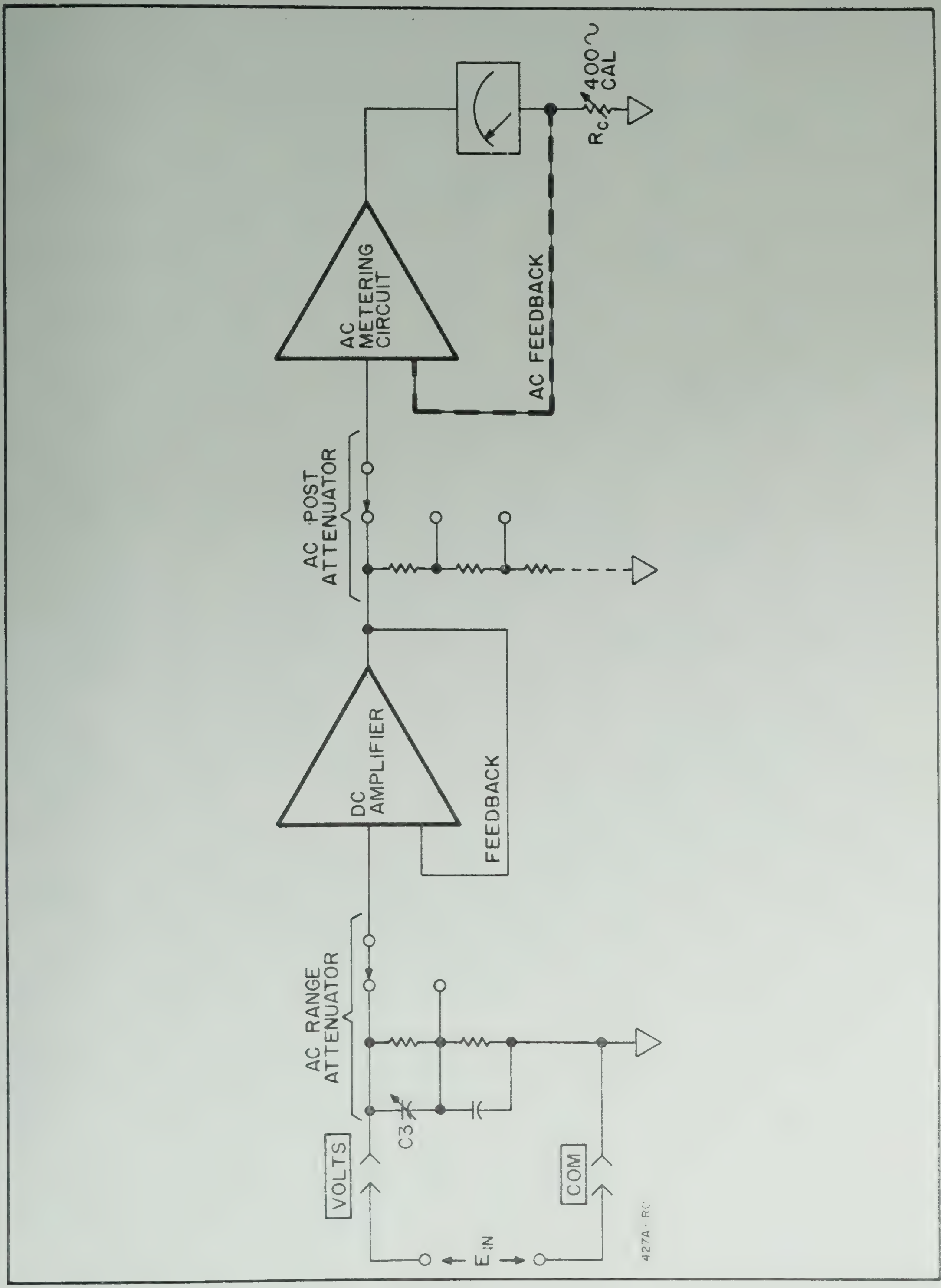


Figure 4-4. AC Operation

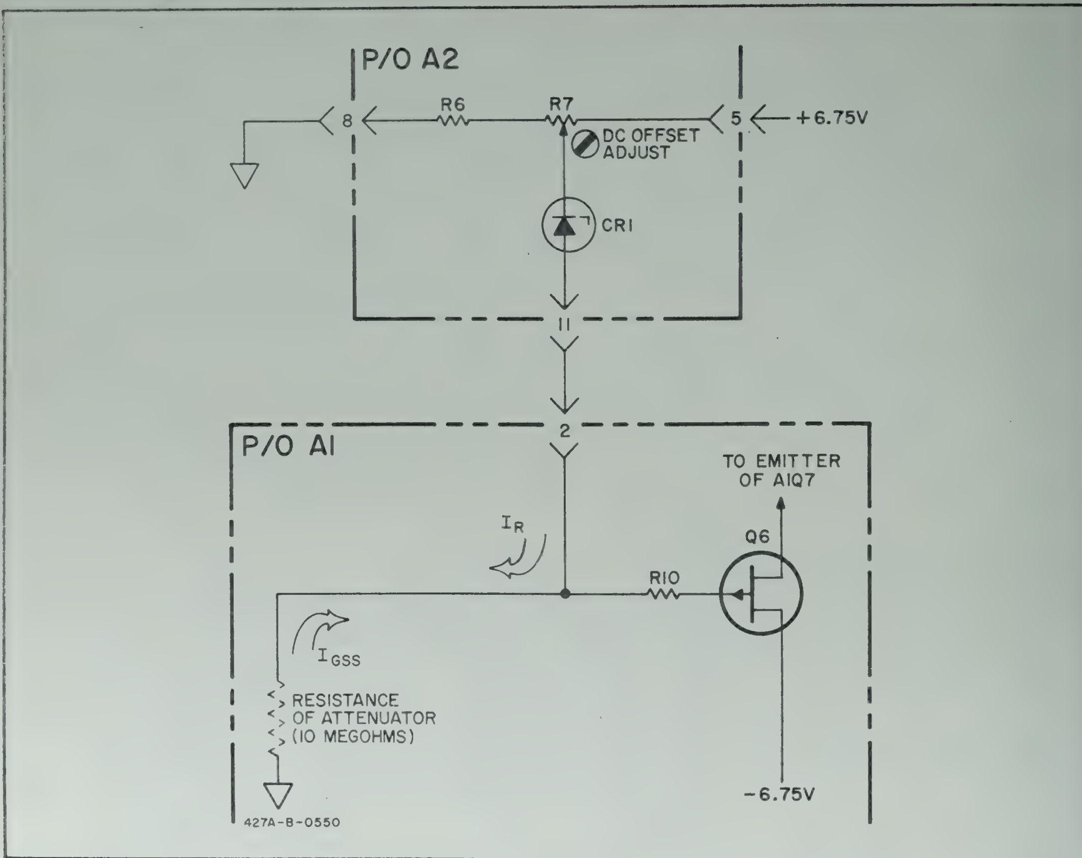


Figure 4-5. DC Offset Circuit

4-19. AC METERING CIRCUIT (A2).

4-20. Figure 6-3 contains the schematic of the ac metering circuit. The ac input from the ac post attenuator is applied through A2C1 to the base of A2Q1. A2Q2 is an emitter follower that provides impedance matching to common emitter output stage A2Q3. Capacitor A2C4 provides an ac feedback path for gain stabilization.

4-21. The output from the collector of A2Q3 is rectified by A2CR3 and A2CR4 and applied to the meter movement.

4-22. Resistor A2R11 is used to calibrate the amplifier at low frequency. A2R11 is adjusted for full scale meter deflection with a 10 mv, 400 Hz input. Capacitor A2C3 is used to calibrate the amplifier at high frequency. With a 10 mv, 1 MHz input, A2C3, adjusted for full scale.

4-23. BATTERY REGULATOR A1 (See Figure 6-3).

4-24. The Battery Regulator regulates the dc voltage from the 22. 5 volt battery or from the optional power supply. Transistors Q1 and Q2 form a series regulator, and transistors Q5, Q6, and Q7 form a reference amplifier. The reference is

supplied by breakdown diode CR2. Diodes CR3, CR4, and CR5 provide temperature stabilization.

4-25. The outputs from the power supply are +6.7 v and -6.7 v.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
DC Voltage* Standard	Range: 0-300 v Accuracy: ±0.2%	Performance Checks	-hp- Model 738BR Voltmeter Calibrator
Test Oscillator*	Frequency Range: 400 Hz to 100 KHz Output: 0 to 3 vac	Performance Checks	-hp- Model 200SR Oscillator
Frequency Response* Test Set	Frequency Response: ±0.5% 400 Hz to 1 MHz Output: 0 to 3 vac	Performance Checks	-hp- Model 739AR Frequency Response Test Set
Decade Resistor	Range: 10 Ω to 10 MΩ Accuracy: ±0.5%	Performance Checks	General Radio Model 1432Z Decade Resistor
DC Voltmeter	Range: 0-50 vdc Accuracy: ±2%	Troubleshooting	-hp- Model 427A Voltmeter
AC Voltmeter	Range: 0-50 vac Accuracy: ±2%	Troubleshooting	-hp- Model 427A Voltmeter

* Contained in -hp- K02-738BR VTVM Calibration System.

SECTION V

MAINTENANCE

NOTE

In this manual, the international standard unit of frequency, the Hertz, will be used rather than cycles per second.

1 Hertz (Hz) = 1 cycle per second

5-1. INTRODUCTION.

5-2. This section contains information necessary to maintain the Model 427A. The following paragraphs describe the Performance Checks, the Calibration Procedures, and the Troubleshooting Procedures.

5-3. REQUIRED EQUIPMENT.

5-4. Table 5-1 is a list of the equipment needed to properly maintain the Model 427A. If the recommended model is not available, use any substitute that meets the required specifications.

5-5. PERFORMANCE CHECKS.

5-6. The Performance Checks are "in cabinet" tests that compare the Model 427A with its specifications. These procedures can be used both for incoming inspection and periodic inspection. If the Model 427A does not meet its specifications, refer to the Alignment and Calibration Procedures, Paragraph 5-25.

5-7. AC ACCURACY AND FREQUENCY RESPONSE CHECK.

5-8. The AC Accuracy and Frequency Response Check requires a test oscillator that is flat within ±0.5% from 5 Hz (cps) to 1 MHz (Mc). The absolute value of the applied voltage must be accurate within ±0.2%. The -hp- Model 738BR Voltmeter Calibrator produces a 400 Hz signal that is within less than 0.2% of the indicated output. The -hp- Model 739AR Frequency Response Test Set and 200SR Oscillator combination can be adjusted to within less than 0.5% of a desired reference from 5 Hz to 5 MHz. In the following procedures, whenever the frequency response test set is used, a set level indication is mentioned. Set level is a meter used to re-establish the proper amplitude each time the frequency is changed.

NOTE

Before beginning the Performance Checks, be sure to adjust the mechanical meter zero according to the steps in Paragraph 3-6.

5-9. AC Accuracy Check.

5-10. Connect the test oscillator, the frequency response test set, and the voltmeter calibrator as shown in Figure 5-1.

a. Set the voltmeter calibrator for an output of 0.01 volts at 400 Hz.

b. Set S1 in Figure 5-1 to position B.

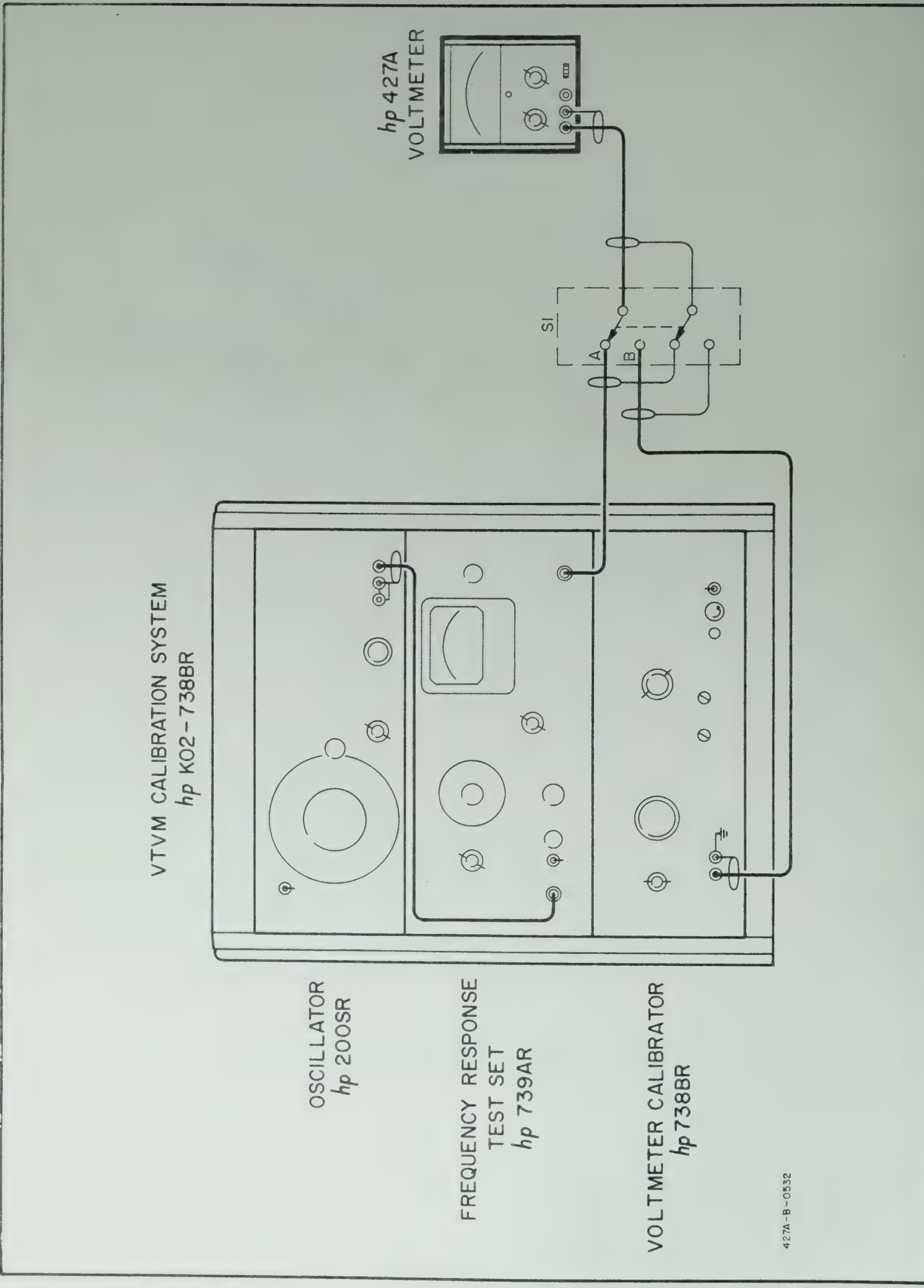


Figure 5-1. AC Accuracy and Frequency Response Check

c. Set the Model 427A FUNCTION to ACV and the RANGE to 0.01.

d. The 427A should read 0.01 volts rms ±2% (2 minor scale divisions).

e. Repeat steps a through d for each ac RANGE selection through 300 v by setting the voltmeter calibrator output to the full scale value for each range. The Model 427A indication should not vary from the known input by more than ±2% on any range. 2% corresponds to 2 minor divisions on the 0-1 scale and 1/2 minor division on the 0-3 scale.

f. Set the Model 427A to the 1 volt range and apply 0.9, 0.8, 0.7, 0.6, 0.5, 0.3, 0.2, and 0.1 volt signals. In each case the reading should be within two minor divisions of the known input signal.

g. Set the Model 427A to the 3 volt range and apply 2.5, 2, 1.5, 1, and 0.5 volt signals. In each case the reading should be within 1/2 minor division of the known input signal.

5-11. Frequency Response Check.

5-12. The frequency range of the frequency response test set used is 300 KHz to 10 MHz. The Model 427A must be checked from 5 Hz to 1 MHz, so an external oscillator is used to drive the frequency response test set at lower frequencies.

a. Set S1 in Figure 5-1 to position A. Set the Model 427A RANGE to 0.01.

b. Set the frequency response test set frequency selector to accept an external oscillator input and set the amplitude control for a 0.01 volt output.

c. Set the oscillator to 400 Hz and adjust the output for a 0.95 indication on the 427A 0-1 scale.

d. Adjust the set level control on the frequency response test set for a convenient meter indication. Record indication for reference in steps e through g.

e. Change the oscillator frequency to 5 Hz and reset the oscillator amplitude for the set level indication in step d. DO NOT readjust the set level control on the frequency response test set. The 427A indication should not vary by more than ±3 minor scale divisions (±3%).

f. Repeat step e for 10 Hz, 100 Hz, 1 KHz, 10 KHz, and 100 KHz. In each case the 427A indication should not vary by more than ±2 minor scale divisions (±2%).

g. Set the frequency response test set for 500 KHz using its internal oscillator. Adjust the amplitude vernier for the set level indication in step d. DO NOT readjust the set level control. The 427A indication should not vary by more than ±2%.

h. Repeat step g with the frequency set at 1 MHz.

5-13. Repeat Paragraphs 5-9 through 5-12 with the 427A RANGE set to 3 volts. The 427A reading should not vary by more than ±2% (±1/2 small scale division).

5-14. RESISTANCE ACCURACY CHECK.

5-15. To check the resistance accuracy, precision resistances are needed. Figure 5-2 shows the resistance accuracy check using a General Radio Model 1432Z decade resistor. The resistance used should be accurate to within ±0.5% and should have a range of 10 ohms to 10 M ohms.

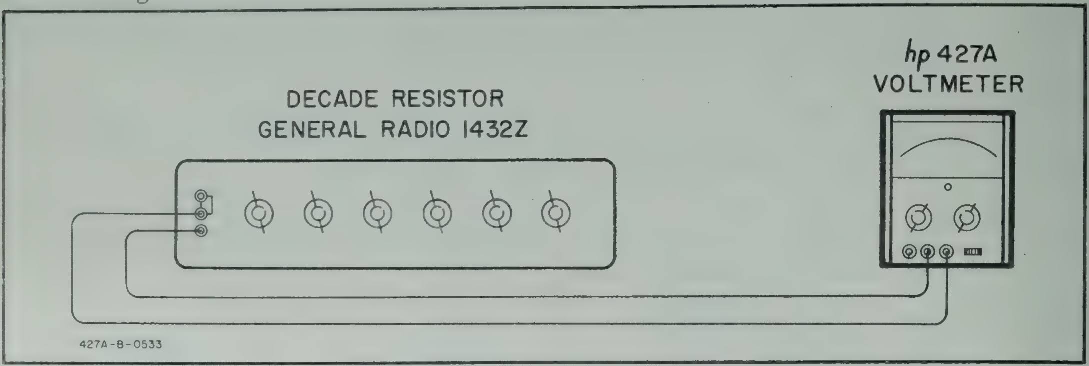


Figure 5-2. Resistance Accuracy Check

a. With the input open, set the Model 427A FUNCTION to OHMS and the RANGE to X10. Adjust the DC ZERO/Ω ∞ adjustment for an indication of ∞ on the meter face. (The needle should rest on the mark just to the left of ∞.)

b. Connect the decade resistor and the Model 427A as shown in Figure 5-2, and set the decade for 10 Ω.

c. The 427A meter should read within ±5% of the known resistance (- one small scale division, + one-half small division).

d. Repeat steps a through c using the RANGE and decade resistor settings listed in Table 5-2.

NOTE

The DC ZERO/Ω ∞ adjustment need only be made on the X10 and X1K ranges.

Table 5-2. Settings for Resistance Accuracy Check

RANGE	DECADE
X100	100 Ω
X1K	1000 Ω
X10K	10 K Ω
X100K	100 K Ω
X1M	1 M Ω
X10M	10 M Ω

5-16. DC ACCURACY AND LINEARITY CHECK.

5-17. The DC Accuracy and Linearity Check requires a dc voltage standard that is accurate to within ±0.2% of its indicated output from 0.1 volt to 300 v. The -hp-

Model 738BR Voltmeter Calibrator is accurate to within ±0.1% of the indicated output. Figure 5-3 shows the test setup for the DC Accuracy and Linearity Check.

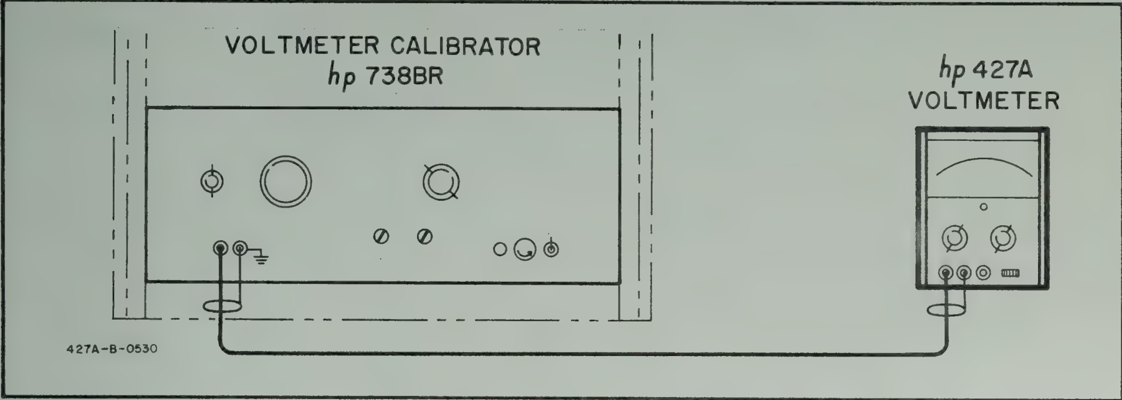


Figure 5-3. DC Accuracy and Linearity Check

a. Set the Model 427A FUNCTION to +DCV and the RANGE to 0.1.

b. Adjust the DC ZERO/Ω ∞ for zero. This adjustment need only be made on the 0.1 volt range.

c. Connect the voltmeter calibrator and the Model 427A as shown in Figure 5-3.

d. Set the voltmeter calibrator output to 0.1 volts dc. The Model 427A should read 0.1 volt ±2%.

e. Repeat steps a through e for each RANGE selection to 300 v by setting the voltmeter calibrator output to the full scale value for each range. The Model 427A indication should not vary from the known input by more than ±2% on any range. 2% corresponds to 2 minor divisions on the 0-1 scale and 1/2 minor division on the 0-3 scale.

f. Set the dc RANGE to 1000 V and the voltmeter calibrator to 300 v. The Model 427A should read 300 v ±2% of full scale on the 1000 volt range.

g. Set the Model 427A to the 1 volt range and apply 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, and 0.1 volt dc signals from the voltmeter calibrator. In each case the reading should be within two minor divisions of the known input voltage.

h. Set the Model 427A to the 3 volt range and apply 2.5, 2, 1.5, 1, and 0.5 volt dc signals. In each case the reading should be within 1/2 division of the known input voltage.

i. Repeat steps a through f with the FUNCTION set to -DCV and the voltmeter calibrator set for a negative output. The test results should be the same.

5-18. AC SUPERIMPOSED NOISE CHECK.

5-19. A peak ac superimposed noise signal 100 times the full scale input should affect the Model 427A reading less than 1%. Figure 5-4 shows the test setup using

a variable line transformer as a noise generator. A 7.07 volt rms output from the variac corresponds to a 10 volt peak noise signal. The 10 volt noise signal will be applied to the 0.1 volt dc range.

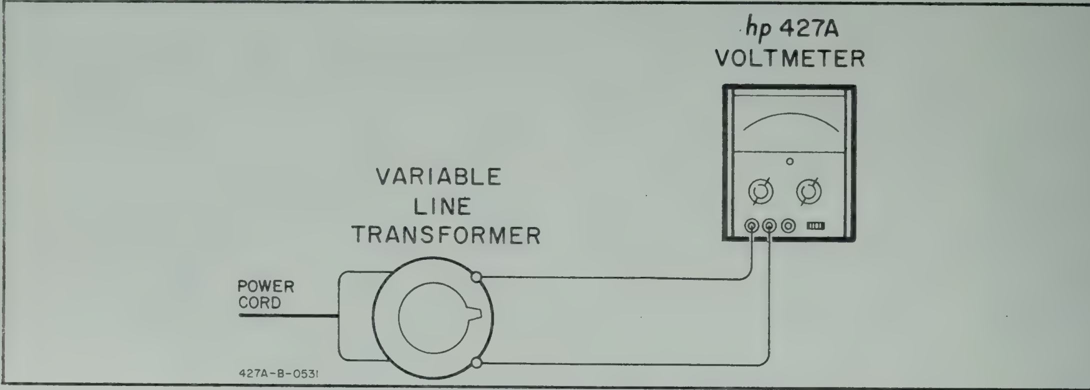


Figure 5-4. AC Superimposed Noise Check

a. Set the 427A FUNCTION to +DCV and short the input. Set the RANGE to 0.1 and adjust the DC ZERO/Ω ∞ for 0 meter indication.

b. Switch the FUNCTION to ACV and the RANGE to 10. Connect the variable line transformer and the Model 427A as shown in Figure 5-4.

c. Adjust the transformer output for a reading of 7.07 volts rms on the 427A.

d. Switch the 427A FUNCTION to +DC and the RANGE to 0.1.

e. The meter should not move more than 1 minor scale division from 0 (±1%).

NOTE

The meter may move upscale momentarily and then return to zero. This indicates the charging of the DC Filter capacitors and is normal.

f. Repeat steps a through e using the 1 volt dc range and 70.7 volt rms signal from the transformer.

5-20. INPUT IMPEDANCE CHECK.

5-21. Input Resistance Check.

5-22. Figure 5-5 shows the setup for the input resistance check. A 1 M Ω resistor is connected in series with the input, and the voltage drop across the input resistance will be:

$$E_R = E_{applied} \left(\frac{R_{in}}{R_{series} + R_{in}} \right)$$

With 1 volt applied, E_R will be 0.91 volt if the input resistance is 10 M Ω. E_R varies directly with changes in R_{in}.

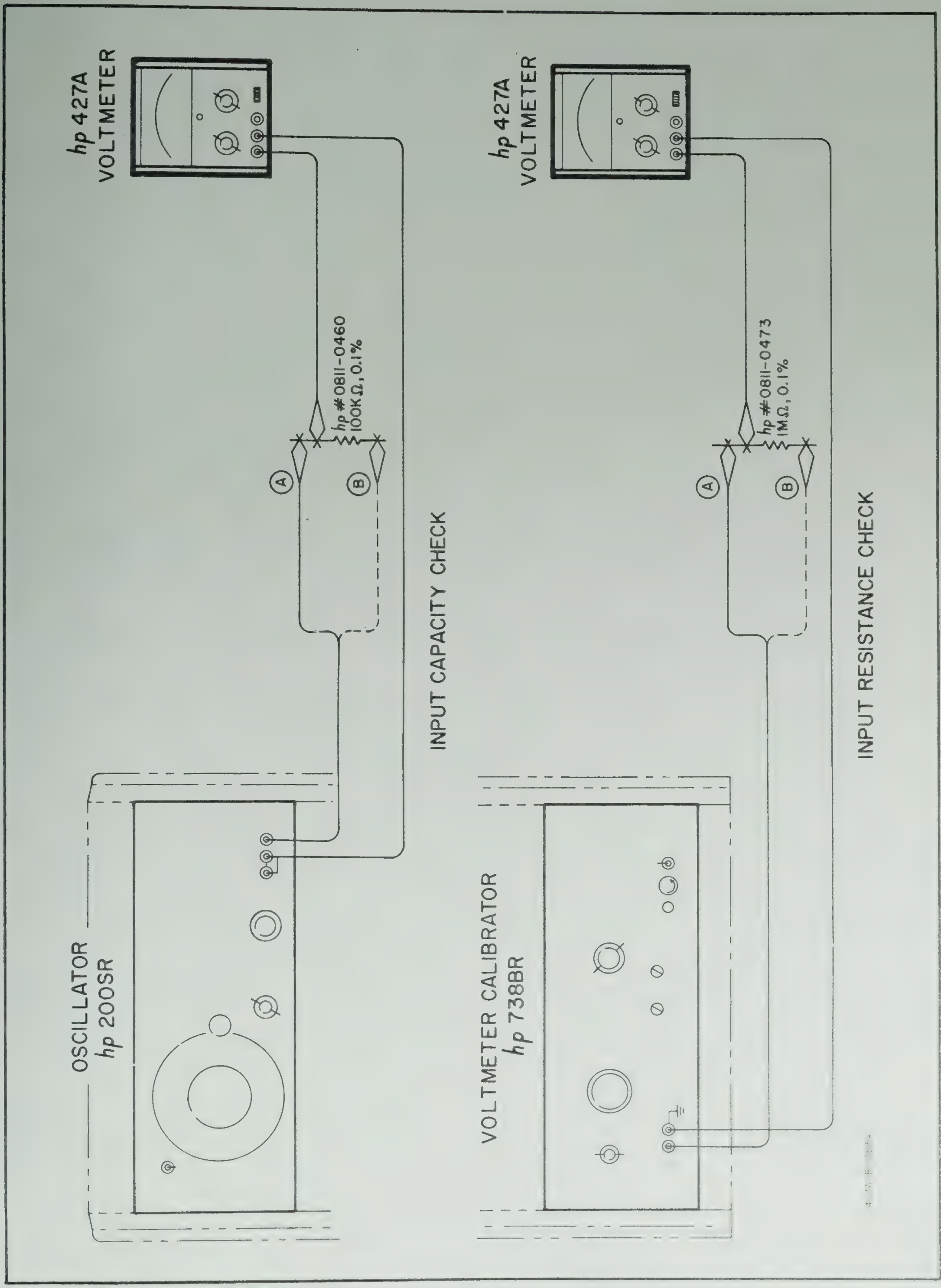


Figure 5-5. Input Impedance Check

a. Connect the Model 427A and the voltmeter calibrator as shown in A of the Input Resistance Check (Figure 5-5). Set the Model 427A FUNCTION to +DCV and RANGE to 1 V.

b. Set the voltmeter calibrator for +1 v.

c. Connect the voltmeter and voltmeter calibrator as shown in part B.

d. The voltmeter reading should drop to 0.91, indicating an input resistance of 10 M Ω. The input resistance may vary slightly, and a tolerance of ±2% should be allowed.

5-23. Input Capacity Check.

5-24. The 10 M Ω input resistance is shunted by about 40 pf on the 0.01 through 1 volt ac ranges and about 20 pf on the 3 through 300 volt ac ranges. For this input capacity check a 100 K Ω resistor is placed in series with the meter input. At a known frequency, the reactance of the shunt capacity will be equal to 100 K Ω. At this point the voltage across the input resistance and shunt capacity will be equal to 0.707 times the input voltage. The input capacity may be checked by finding the frequency at which the displayed voltage drops to 0.707 times the input. As the roll off frequency increases, the input capacity decreases, and vice versa.

a. Connect an oscillator and the Model 427A as shown in A of the input capacity check (Figure 5-5), and set the Model 427A FUNCTION to ACV and RANGE to 1 V.

b. Set the oscillator frequency to 60 Hz and adjust the amplitude for a full scale display on the Model 427A.

c. Connect the oscillator as shown in B and increase the frequency until the meter display drops to 0.707. The frequency at this point should be about 40 KHz. The input capacity is nominally specified at 40 pf and may vary from instrument to instrument. A frequency variation of ±10% is acceptable.

d. Repeat steps a through c using the 3 volt range of the 427A. Increase the frequency in step c until the reading drops to 2.1 volts. This should occur at about 80 KHz.

5-25. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-26. The following adjustment and calibration procedures should be used only if it has been determined through the performance checks in Paragraphs 5-5 through 5-24 that the Model 427A is not performing within its specifications. The location of the internal adjustments is shown in Figures 5-6 and 6-2.

5-27. COVER REMOVAL.

5-28. To remove the top or bottom covers, remove the Phillips screw at the rear of the cover, slide the cover about 1 inch to the rear, and lift it off. To replace the cover, reverse the removal procedure.

5-29. To remove a side cover, remove the four Phillips screws and lift if off.

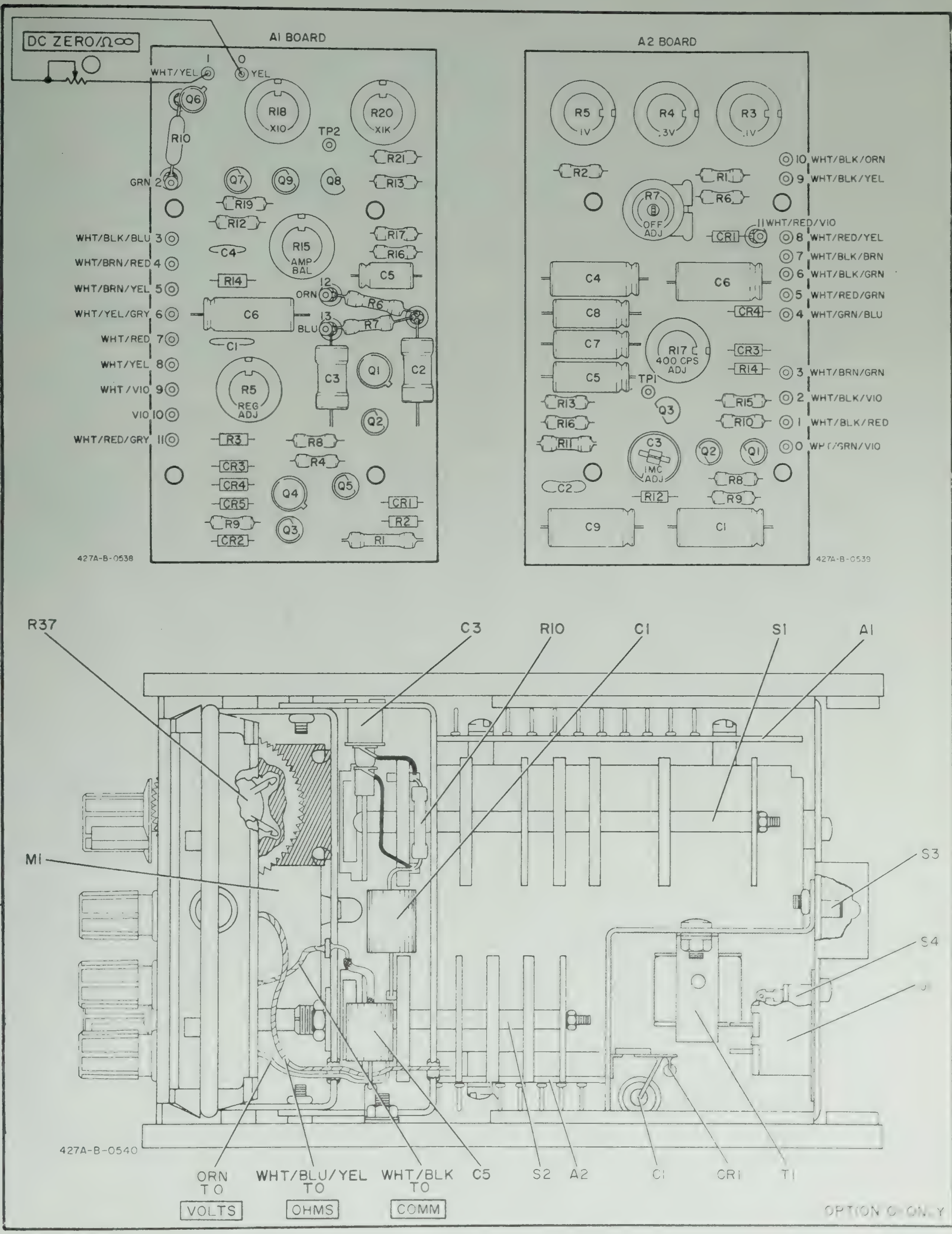


Figure 5-6. Location of Internal Adjustments

NOTE

Before beginning the Calibration, be sure to adjust the mechanical meter zero according to the steps in Paragraph 3-6.

5-30. AMPLIFIER BALANCE AND ZERO OFFSET ADJUSTMENT.

a. Set the FUNCTION to +DCV and turn DC ZERO/Ω ∞ fully to the right. Set Range to 0.1. Record position of indicator.

b. Turn FUNCTION to -DCV and rotate DC ZERO/Ω ∞ fully to the left. Note position of indicator.

c. Repeat steps a and b and adjust A1R15 AMP BAL until the indicator position in both steps is approximately the same.

d. Short VOLTS and COM terminals, set FUNCTION to either +DCV or -DCV.

e. Set DC ZERO/Ω ∞ for zero deflection.

f. Remove shorting connection from VOLTS and COM terminals. If meter deflects, adjust A2R7 OFF ADJ for zero deflection. Short VOLTS and COM terminals and recheck zero adjustment. Repeat steps e and f if necessary.

5-31. REGULATOR ADJUST.

a. Complete Amplifier Balance and Offset adjustment (Paragraph 5-30).

b. Short VOLTS to COM and OHMS to COM. Set FUNCTION to +DCV. Meter should be zeroed.

c. Switch FUNCTION to OHMS. If meter deflects, adjust A1R5 REG ADJ for zero deflection. This may affect +DCV zero setting, so rotate FUNCTION back and forth between OHMS and +DCV and check that meter does not deflect. If it does, readjust A1R5.

5-32. AC CALIBRATION.

5-33. Three adjustments must be made to calibrate the ac circuits in the Model 427A. First, A2R17 adjusts the absolute amplitude calibration with a 10 mv 400 Hz input. Then A2C3 is adjusted with a 10 mv 1 MHz input to calibrate the high frequency response. Finally the frequency response of the AC Range Attenuator must be set with a 3 v 100 KHz input by adjusting C3.

5-34. <u>Low Frequency Calibration.</u>

a. Connect the Model 427A as shown in Figure 5-1 to adjust the low frequency calibration. Set S1 to position B.

b. Set the voltmeter calibrator output to 400 Hz at 0.01 volt rms, and set the 427A RANGE to 0.01 and FUNCTION to ACV.

c. Adjust A2R17 400 CPS for exactly 0.01 volt indication on the 427A.

5-35. High Frequency Calibration.

a. Connect the Model 427A as shown in Figure 5-1. Set S1 to position A. Set 427A RANGE to 0.01 and FUNCTION to ACV.

b. Set the frequency response test set frequency selector to accept an external oscillator input and set the amplitude control for a 0.01 volt output.

c. Set the oscillator to 400 Hz and adjust the output for exactly a 0.01 volt indication on the 427A.

d. Adjust the set level control on the frequency response test set for a convenient meter indication.

e. Set the frequency response test set for 1 MHz using its internal oscillator. Adjust the amplitude vernier for the set level indication in step d. DO NOT readjust the set level control.

f. Adjust A2C3 1 MC ADJ for exactly a 0.01 volt indication on the Model 427A.

g. Rotate 427A RANGE switch to 3, set S1 to position B. Adjust the voltmeter calibrator for an output of 3 v at 400 Hz.

h. Change S1 to position A. Set the oscillator to 400 Hz, set the frequency response test set for an external oscillator input, and adjust both the oscillator and test set controls for an indication of 3 on the 427A 0-3 scale.

i. Adjust the set level control for a convenient reference and increase the oscillator frequency to 100 KHz. Reset the oscillator amplitude for the set level.

j. Adjust C3 for exactly a 3 volt indication on the 427A.

5-36. RESISTANCE INFINITY ADJUSTMENT.

5-37. No equipment is needed to calibrate the resistance circuits, and only the X10 and X1K ranges require calibration.

a. Set FUNCTION to OHMS and RANGE to X10.

b. Short OHMS to COM and adjust the DC ZERO/Ω ∞ for zero. Open the input and adjust A1R18 for an ∞ indication. The indicator should rest on the mark just to the left of ∞.

c. Change RANGE to X1K, short OHMS to COM and adjust DC ZERO/ Ω ∞ for zero. Open the input and adjust A1R20 for an ∞ indication.

5-38. DC CALIBRATION.

5-39. A dc voltage standard is needed to calibrate the dc ranges. A2R3, A2R4, and A2R5 are adjusted for full scale inputs on the 0.1, 0.3, and 1 volt ranges respectively. The 3 volt through 1000 volt ranges are calibrated by A2R5 and require no special calibration. Use the test setup in Figure 5-3.

a. Set FUNCTION to +DCV and RANGE to 0.1. Set the voltmeter calibrator output to +0.1 volt.

b. Adjust A2R3 for full scale on the 0-1 scale.

c. Rotate RANGE to 0.3, and change the calibrator output to +0.3 volt.

d. Adjust A2R4 for 3 on the 0-3 scale.

e. Rotate RANGE to 1 and change the calibrator output to 1 volt.

f. Adjust A2R5 for full scale on the 0-1 scale.

5-40. ALTERNATE PERFORMANCE CHECKS AND CALIBRATION PROCEDURES.

5-41. The following alternate procedures should be used only if the equipment in Table 5-1 is not available. In each alternate procedure use an instrument of the specified accuracy. If a less accurate instrument is used, the calibration or test will not be within the Model 427A specifications. The calibration will be as accurate as the instruments used.

5-42. AC CIRCUITS.

5-43. Any test oscillator with low distortion (<2%) may be used as an ac voltage standard. If the distortion level is too high, the calibration may be wrong, as the 427A is an average responding rms calibrated meter. (The effects of harmonic distortion are discussed in more detail in Section III, Paragraphs 3-14 and 3-15.)

5-44. Monitor the output with a recently calibrated rms voltmeter known to be at least twice as accurate as the Model 427A over the same band of frequencies. The rms voltmeter serves as a reference. Each time the oscillator frequency is changed, readjust the output for the reference. The Model 427A ac calibration is based on a 400 Hz absolute reference, so always start the ac calibration or performance checks at 400 Hz.

5-45. RESISTANCE CIRCUITS.

5-46. If a decade resistor is not available, any selection of precision resistors may be used. The resistors should be at least 1% resistors and the values selected should correspond to the RANGE settings.

5-47. DC CIRCUITS.

5-48. A precision dc voltage source is required for dc calibration and performance checks. Since the 427A is only calibrated on the 1 volt, 0.3 volt and 0.1 volt ranges, only three different voltages are needed.

5-49. A mercury battery has good short term stability. Connect a series voltage divider with a variable output across the battery and monitor the output with a recently calibrated dc voltmeter known to at least twice as accurate as the Model 427A. Use the output to calibrate the 0.1, 0.3, and 1 volt ranges.

5-50. INPUT IMPEDANCE CHECK.

5-51. Measure the resistance between the VOLTS and COM terminals directly with the Model 427A Function Switch at +DCV or -DCV using an accurate ohmmeter. Another Model 427A could be used for this purpose. If an L-C meter of capacitance bridge is available, measure the input capacitance between the VOLTS and COM terminals directly. Be sure the Model 427A FUNCTION switch is in the ACV position.

5-52. BATTERY REPLACEMENT.

5-53. Figure 5-7 shows the battery holder and the battery connections. Turn the twist-lock fastener 1/4 turn counterclockwise, tilt the battery and holder toward the rear of the instrument, and lift out. Replace the battery with an Eveready 763 or RCA VS102 22-1/2 volt dry cell battery.

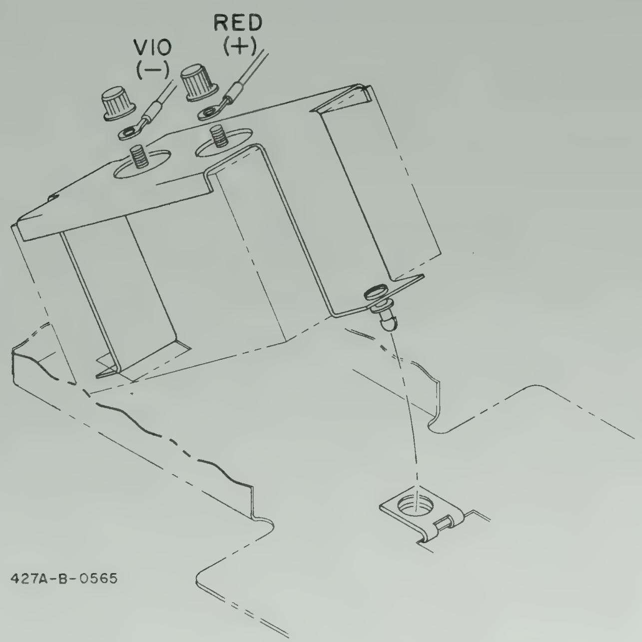


Figure 5-7. Battery Replacement

5-54. TROUBLESHOOTING.

5-55. When the Model 427A operates improperly, first adjust and calibrate it according to the procedures in Paragraph 5-25. If calibration is impossible, then proceed with the troubleshooting steps.

5-56. Check the instrument for obvious evidence of trouble, such as loose or broken wires or broken connectors. Check the printed circuit boards for cracks and separations, and ensure that all connectors and pins are clean and tight.

5-57. Isolate the trouble to a particular circuit using the troubleshooting table (Table 5-3) and the Theory of Operation (Section IV). Then refer to the troubleshooting steps for that circuit.

5-58. POWER SUPPLY.

5-59. Check at A1 pin 7 for +6.7 volts and A1 pin 9 for -6.7 volts. If there is no output, check A1Q4 first. If the power supply has been overloaded, A1Q4 is likely to be bad.

5-60. Measure the dc voltages at the check points in Table 5-4. If a given reading is wrong, the trouble is either in that component or its associated circuit.

Table 5-3. Troubleshooting

SYMPTOM	PROBABLE TROUBLE AREA
Battery OK, no response to input.	Power Supply. (See Paragraph 5-58.)
All +DCV ranges pegged with no input. AC and OHMS OK.	Dc offset circuit. Check A2CR1. Then check A1Q6.
Nonlinear tracking on voltage ranges.	DC Amplifier. Check A1Q8 and associated circuit. Check value of range resistors.
Constant upscale deflection on lower +DCV ranges; voltage at TP1 low.	DC Amplifier. (See Paragraph 5-61.)
Meter pegs on +dc and ohms ranges.	DC Amplifier; check A1Q6, A1Q8 and A1Q9. (See Paragraph 5-63 .)
Ohms range always reads near zero, DC and AC OK.	Range resistors (R_a) open. Check R19 through R25 on S1. Range resistors (R_b) shorted. Check R12 through R18. Check Power Supply.
Ohms always reads ∞. DC and AC OK.	Either one of R19 through R25 (R_a) shorted or one of R12 through R18 open.

Table 5-4. Power Supply Voltages

NOTE

The voltages listed in this table are nominal. A tolerance of ±10% should be allowed.

CHECK POINT	VOLTAGE
Emitter A1Q1	+14.0 v
Collector A1Q1	+ 7.3 v
Base A1Q1	+13.8 v
Emitter A1Q2	+ 6.2 v
Collector A1Q2	+ 7.3 v
Emitter A1Q3	- 0.5 v
Base A1Q3	0 v
Collector A1Q3	- 0.15 v
Collector A1Q4	- 6.7 v
Emitter A1Q4	0 v
Base A1Q5	+ 0.5 v
Across A1CR2	+ 6.2 v

5-61. DC AMPLIFIER.

5-62. To make an operational check of the DC Amplifier, set the RANGE switch to 1 and the FUNCTION switch to +DCV. Connect a 1 volt source to the VOLTS and

COM terminals and monitor the voltage at A1 pin 8. Since the DC Amplifier is a unity gain amplifier, the voltage should be +1.07 ±0.07 volts dc. If this reading is correct, the dc amplifier is operating properly. If it is incorrect, proceed with the troubleshooting procedures.

5-63. Check at the collector of A1Q9 for +3.5 vdc, and check for +3.0 vdc at A1TP1. If the voltage at the collector of A1Q9 is quite high (6 or 7 volts) and the voltage at A1TP1 is +3.0 vdc, A1Q9 is probably open. If the collector voltage is low and the test point voltage is correct, A1Q8 is probably shorted. If both voltages are incorrect, A1Q7 or A1Q8 are probably bad.

5-64. If the collector voltage on A1Q9 is correct and the voltage at A1TP1 is slightly higher than normal, A1Q6 is probably bad.

5-65. AC METERING CIRCUIT.

5-66. To check the AC Metering Circuit, set the RANGE to 0.01 and the FUNCTION to ACV. Connect a 10 mv rms source to the VOLTS and COM terminals and monitor the signal at A2 pin 0. The signal at A2 pin 0 should be 10.7 mv rms ±0.7 mv. If the measured signal is incorrect, the trouble is in either the DC Amplifier or the AC Post Attenuator.

5-67. Monitor the signal at the collector of A2Q3. The signal should be .28 v rms ±.04 v. If the measured signal is correct, the AC Metering Circuit is functioning properly. If not, proceed with the troubleshooting procedures.

5-68. Check the dc bias voltages listed in Table 5-5. If a given reading is wrong, the trouble is probably in that component or its associated circuit.

Table 5-5. AC Metering Circuit Test Voltages

NOTE

The voltages listed in this table are nominal. A tolerance of ±10% should be allowed.

CHECK POINT	VOLTAGE
A2TP1	+2.8 v
A2Q1 Collector	+2.8 v
A2Q2 Emitter	+2.2 v
A2Q3 Collector	-0.5 v

5-69. <u>ADJUSTMENT OF FACTORY SELECTED COMPONENTS.</u>

5-70. Certain components within the Model 427A are individually selected in order to compensate for slightly varying circuit parameters. These components are denoted by an asterisk (*) on the schematic, and the typical value is shown. The following paragraphs describe the function of the factory selected components and give instructions for their selection. Normally these components do not need to be changed unless another associated component is changed. Replacement of a transistor may require the changing of an associated factory selected component.

5-71. A1R19*.

5-72. A1R19* adjusts the range of the Amplifier Balance resistor A1R15. If A1Q6 is changed, A1R19* may need to be changed. If the amplifier balance cannot be

adjusted properly according to the procedure in Paragraph 5-30, use the following steps to select A1R19*.

a. Set RANGE to 0. 3.

b. Set DC ZERO/Ω ∞ adjustment to center and A2R15 to its center.

c. Select the function (+DCV OR -DCV) which will produce an upscale deflection.

d. If the function selected is -DCV, increase the value of A1R19*; if +DCV is selected, decrease A1R19*. The limits of A1R19* are 0 to 1850 Ω.

NOTE

If the upscale deflection in step c is quite small, A1R19* need not be adjusted.

5-73. A2C2*.

5-74. A2C2* adjusts the range of the high frequency calibration capacitor A2C3. If during the high frequency calibration (Paragraph 5-35) A2C3 cannot be adjusted for the proper reading, the value of A2C2 should be changed. If the reading is consistently high, change the value of A2C2* to 47 pf. If the reading is consistently low, remove A2C2*.

5-75. A2R16*.

5-76. A2R16* adjusts the range of the low frequency adjustment A2R17. If A2R17 can't be adjusted for the proper indication during the low frequency calibration (Paragraph 5-34), A2R16* must be changed. If the reading is consistently high, change A2R16 to 56. 2 Ω. The reading cannot be consistently low.

5-77. <u>ETCHED CIRCUIT BOARD REPAIR.</u>

5-78. The Model 427A uses plated-through double-sided etched circuit boards. To prevent damage to the circuit board and components, observe the following rules when soldering:

a. Use a low-heat (25 to 50 watts) soldering iron with a small tip (1/16" to 3/32" dia.).

b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component and then remove the leads from the board.

CAUTION

EXCESSIVE OR PROLONGED HEAT CAN LIFT THE CIRCUIT FOIL FROM THE BOARD OR CAUSE DAMAGE TO COMPONENTS.

c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, non-metallic object such as a toothpick.

d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.

e. Clip excess leads off after soldering and clean excess flux from the connection and adjoining area, using type TF Freon (-hp- Part No. 8500-0232).

SECTION VI

CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

6-2. This section contains the schematic diagram of the Model 427A and the circuit diagrams. Figure 6-1 shows the layout of both the FUNCTION and RANGE switches. The switches are viewed from the bottom with the switches flattened out. The front of the instrument is at the bottom of the page.

6-3. Figure 6-2 shows the layout of the two circuit boards and the bottom view of the instrument. Figure 6-3 is the schematic diagram of the Model 427A.

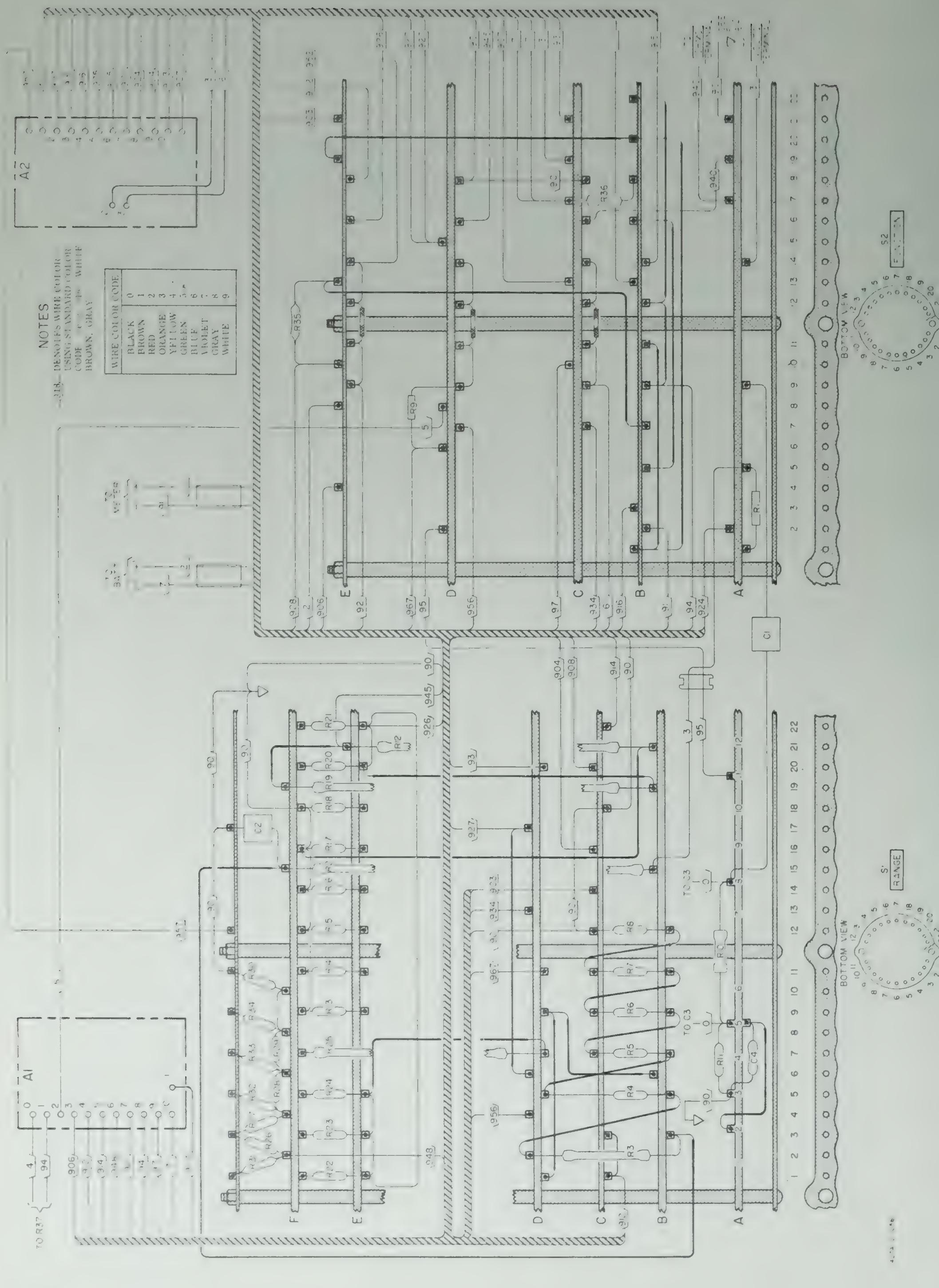


Figure 6-1. Location of Switch Components

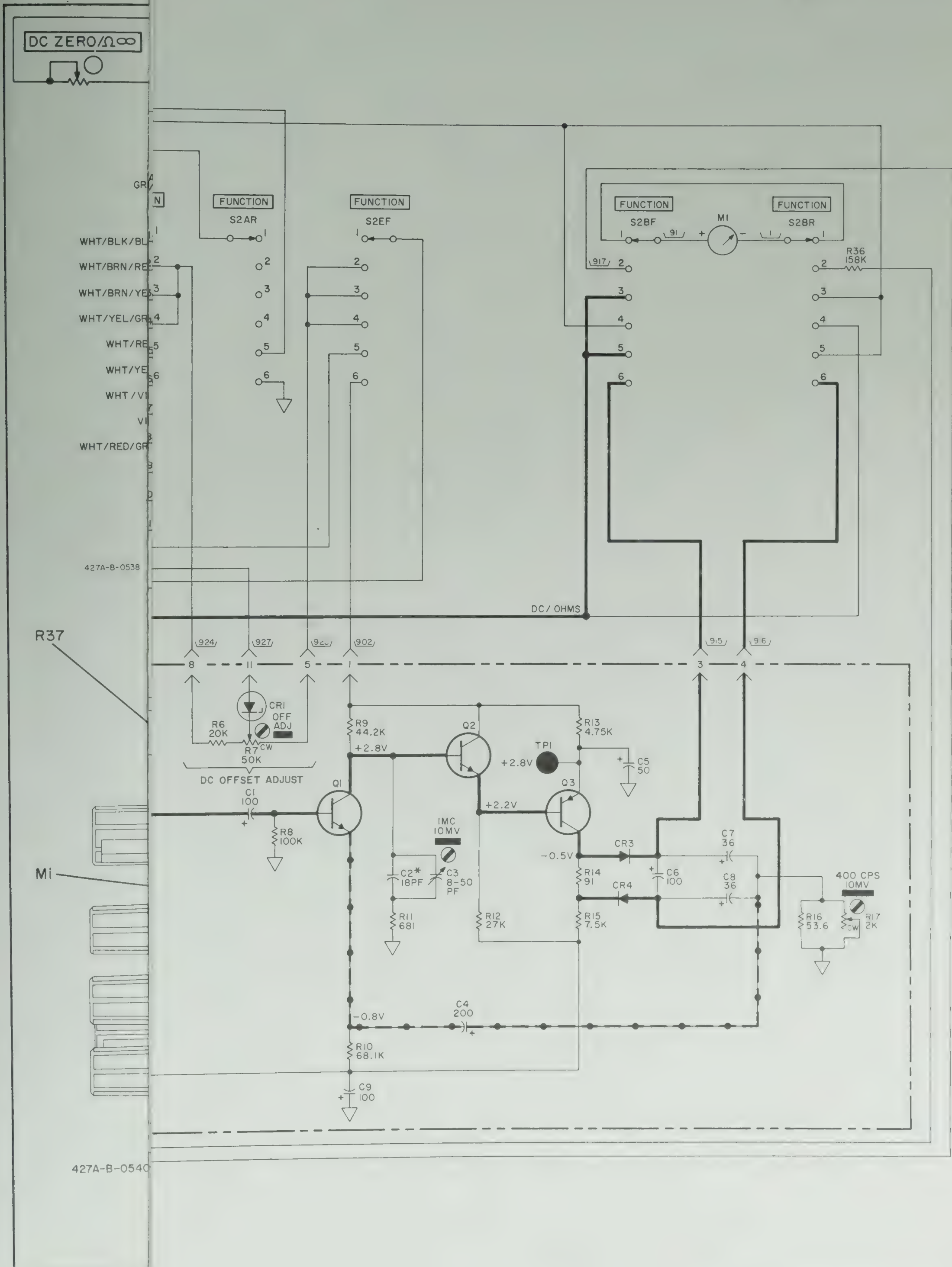


Figure 6-3. Schematic Diagram

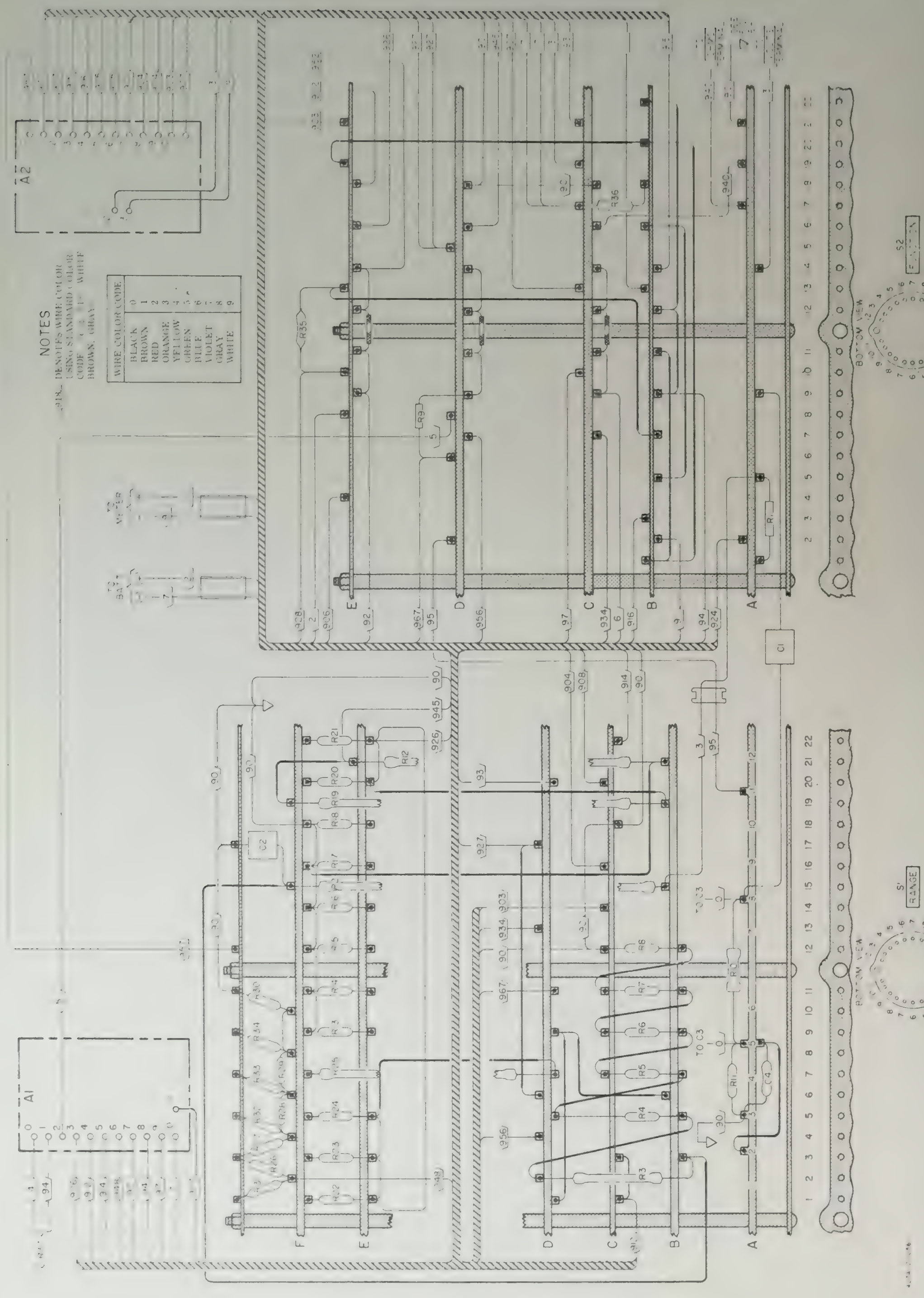


Figure 6-1. Location of Switch Components

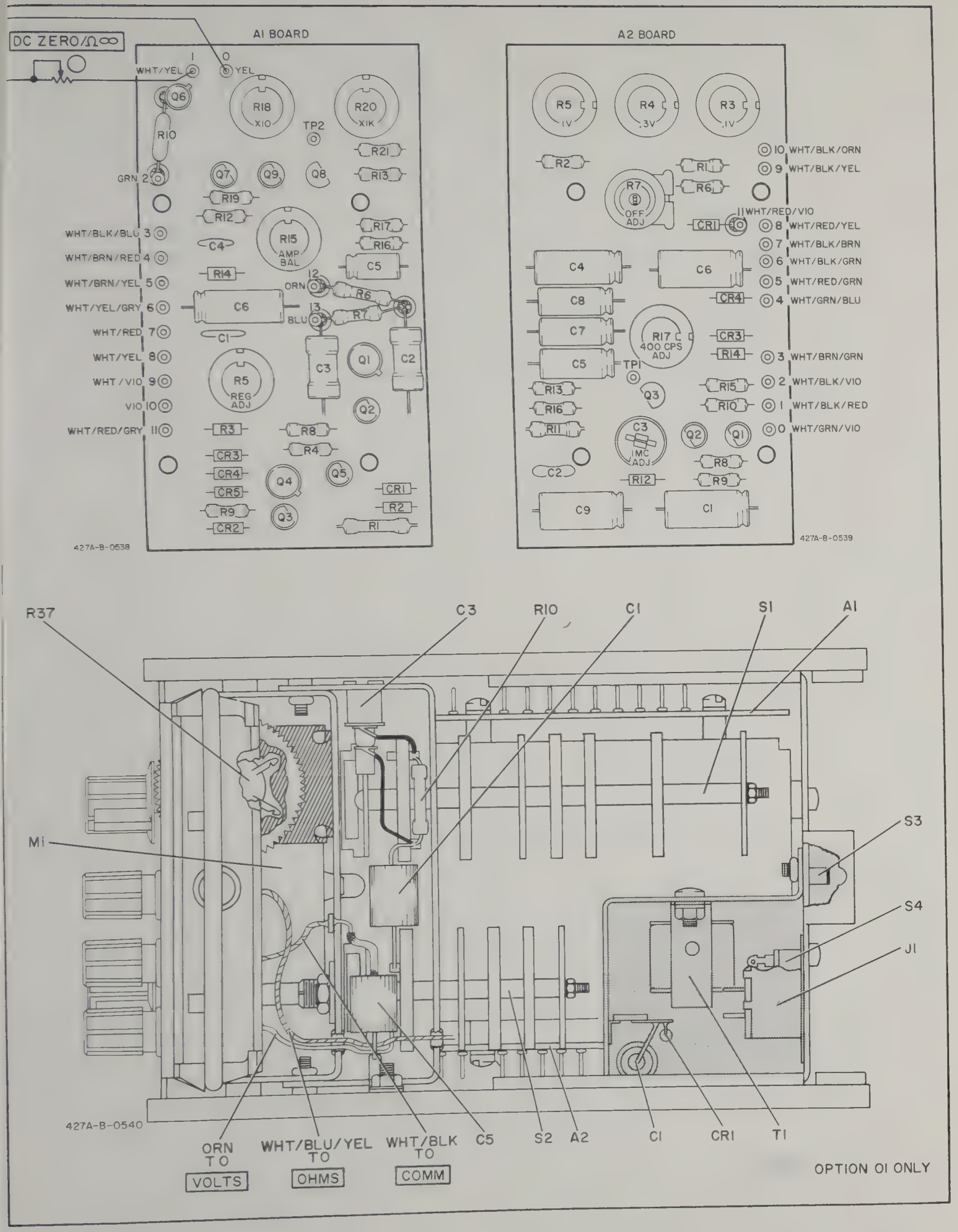
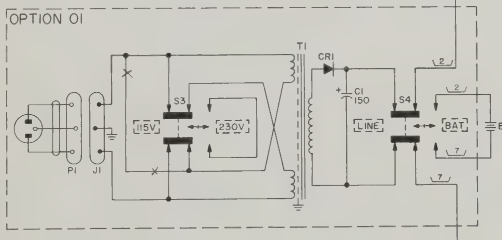
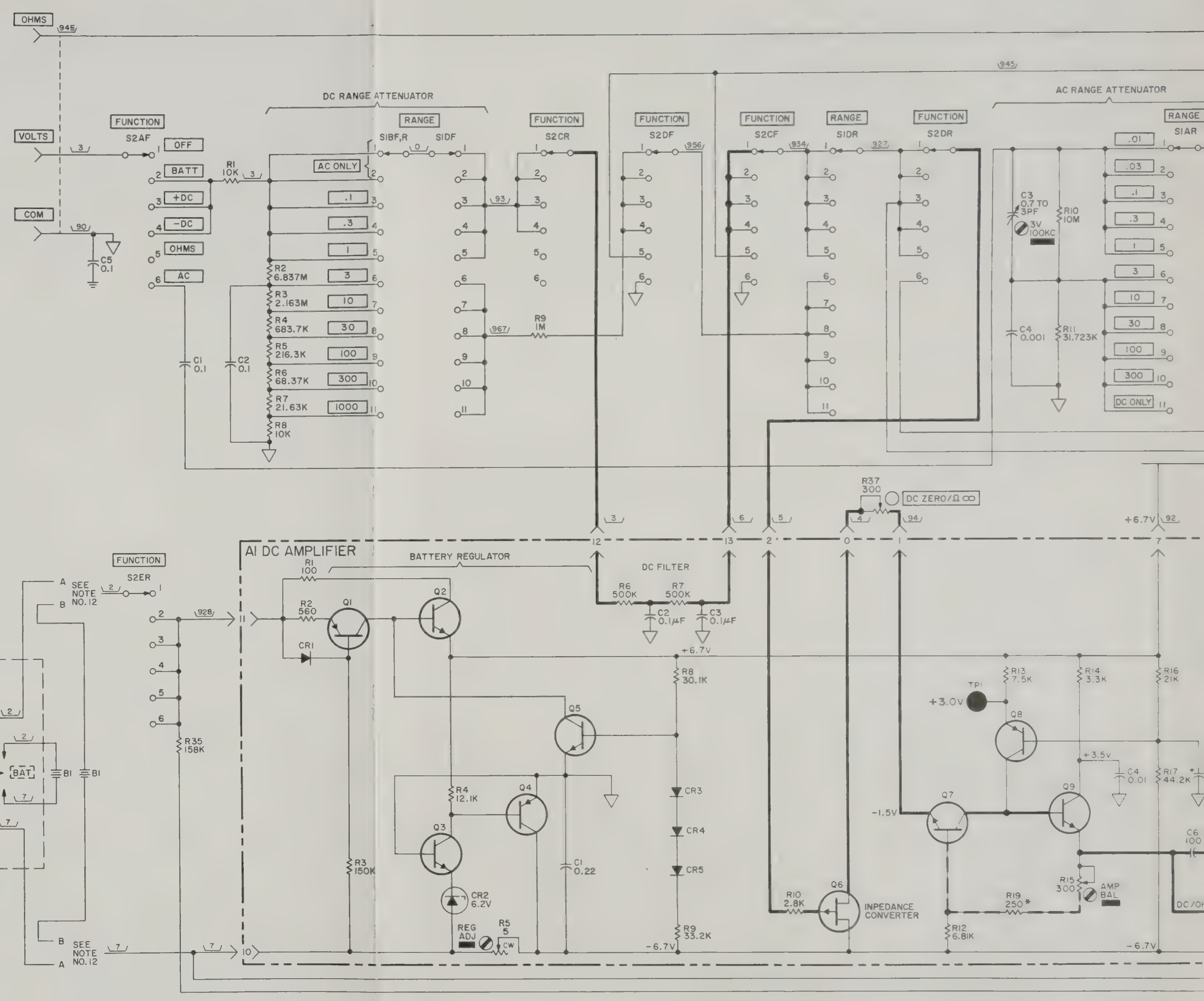


Figure 6-2. Component Location

NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. DENOTES ASSEMBLY.
4. DENOTES OPTION 01.
5. DENOTES MAIN SIGNAL PATH.
6. DENOTES DC FEEDBACK PATH.
7. DENOTES AC FEEDBACK PATH.
8. DENOTES FRONT PANEL MARKING.
9. DENOTES REAR PANEL MARKING.
10. DENOTES SCREWDRIVER ADJUST.
11. DENOTES KNOB ADJUSTMENT.
12. CONNECTED TO "A" IN OPTION 01 INSTRUMENT; CONNECTED TO B IN STANDARD INSTRUMENT.
13. 918 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 = WHITE, BROWN, GRAY)





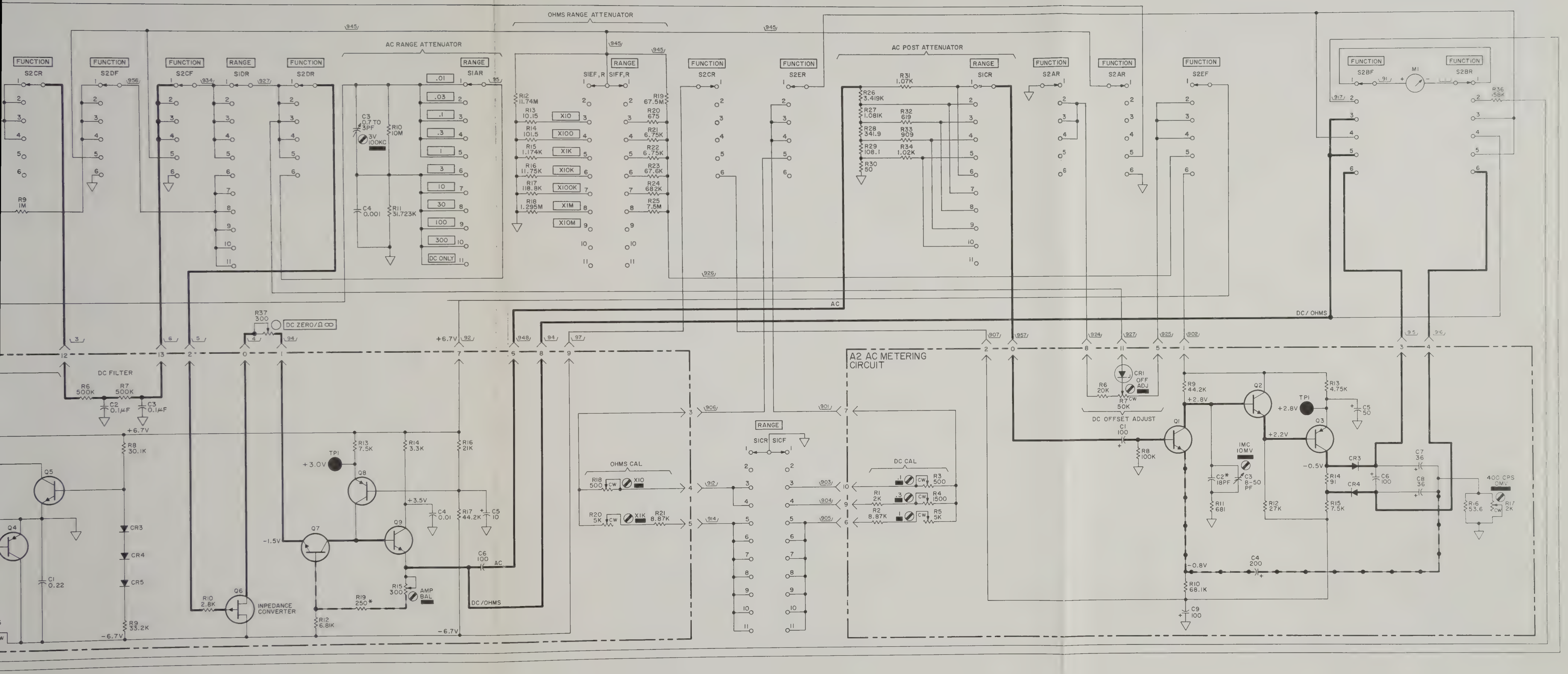


Figure 6-3. Schematic Diagram

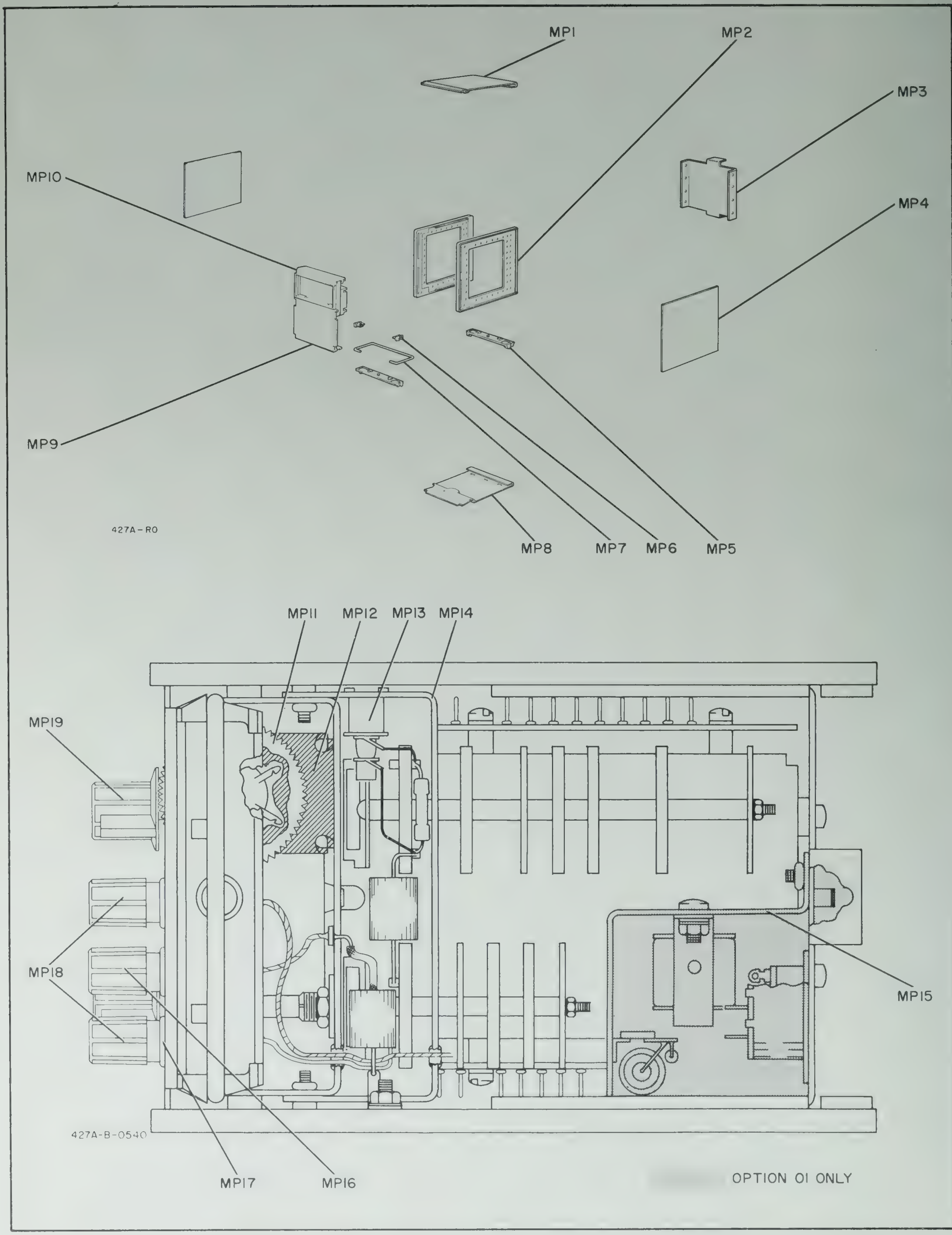


Figure 7-1. Location of Mechanical Parts

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column).

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers.

7-6. NON-LISTED PARTS.

7-7. To obtain a part that is not lised, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly
B	= motor
BT	= battery
C	= capacitor
CR	= diode
DL	= delay line
DS	= lamp
E	= misc electronic part
F	= fuse
FL	= filter
HR	= heater
J	= jack
K	= relay
L	= inductor
M	= meter
MP	= mechanical part
P	= plug
Q	= transistor
QCR	= transistor-diode
R	= resistor
RT	= thermistor
S	= switch
T	= transformer
TC	= thermocouple
V	= vacuum tube, neon bulb, photocell etc.
W	= cable
X	= socket
XDS	= lampholder
XF	= fuseholder
Z	= network

ABBREVIATIONS

Ag	= silver
Al	= aluminum
amp	= ampere (s)
Au	= gold
C	= capacitor
cer	= ceramic
coef	= coefficient
com	= common
comp	= composition
conn	= connection
cps	= cycles per second
dep	= deposited
DPDT	= double-pole double-throw
DPST	= double-pole single-throw
elect	= electrolytic
encap	= encapsulated
f	= farad (s)
FET	= field effect transistor
fxd	= fixed
GaAs	= gallium arsenide
Gc	= gigacycle (s) = 10^{+9}
gd	= guard (ed)
Ge	= germanium
grd	= ground (ed)
h	= henry (ies)
Hg	= mercury
ID	= inside diameter
impg	= impregnated
incd	= incandescent
ins	= insulation (ed)
K	= kilohm (s) = 10^{+3}
Kc	= kiloycycle (s) = 10^{+3}
L	= inductor
lin	= linear taper
log	= logarithmic taper
m	= milli = 10^{-3}
ma	= milliampere (s) = 10^{-3}
Mc	= megacycle (s) = 10^{+6}
meg	= megohm (s) = 10^{+6}
met flm	= metal film
mfr	= manufacturer
mtg	= mounting
μ	= micro = 10^{-6}
my	= Mylar ®
na	= nanoampere (s) = 10^{-9}
NC	= normally closed
Ne	= neon
NO	= normally open
NPO	= negative positive zero (zero temperature coefficient)
ns	= nanosecond (s) = 10^{-9}
nsr	= not separately replaceable
obd	= order by description
OD	= outside diameter
p	= peak
pc	= printed circuit
pf	= picofarad (s) = 10^{-12}
piv	= peak inverse voltage
p/o	= part of
pos	= position (s)
poly	= polystyrene
pot	= potentiometer
p-p	= peak-to-peak
prec	= precision (temperature coefficient, long term stability, and/or tolerance)
R	= resistor
Rh	= rhodium
rms	= root-mean-square
rot	= rotary
Se	= selenium
sect	= section (s)
Si	= silicon
sl	= slide
SPDT	= single-pole double-throw
SPST	= single-pole single-throw
Ta	= tantalum
TiO_2	= titanium dioxide
tog	= toggle
tol	= tolerance
trim	= trimmer
TSTR	= transistor
v	= volt (s)
vacw	= alternating current working volt (s)
var	= variable
vdcw	= direct current working volt (s)
w	= watt (s)
w/	= with
wiv	= reverse working voltage
w/o	= without
ww	= wirewound
*	= optimum value selected at factory, average value shown (part may be omitted)
**	= no standard type number assigned (selected or special type)

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REV D

Table 7-1. Replaceable Parts

REF DESIG	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO
A1	00427-66501		1	Assembly: board DC Amplifier includes C1 thru C6 Q1 thru Q9 CR1 thru CR3 R1 thru R21	28480	00427-66501
A1C1	0160-0170		1	C: fxd cer 0.22 µf +80% -20% 25 vdcw	56289	5C9A obd
A1C2, A1C3	0160-0168		2	C: fxd 0.1 µf ±10% 200 vdcw	56289	192P10492
A1C4	0150-0093		1	C: fxd 0.01 µf +80% -20% 100 vdcw	91418	TA obd
A1C5	0180-0224		1	C: fxd Al elect 10 µf +75% -10% 15 vdcw	56289	30D106G015BA4
A1C6	0180-1800		1	C: fxd Al elect 100 µf +100% -10% 6 vdcw	56289	Non-polar 30D type obd
A1CR1	1901-0025		1	Diode: Si 100 ma at +1 v 100 piv 12 pf	28480	1901-0025
A1CR2	1902-0568		1	Diode: breakdown 6.2 v ±5%	12954	DZ50801U
A1CR3 thru A1CR5	1910-0022		5	Diode: Ge HD1872	03877	obd
A1Q1	1850-0111		1	TSTR: Ge PNP 2N404A	01295	2N404A
A1Q2	1854-0087		1	TSTR: Si NPN 2N3417	24446	2N3417
A1Q3	1854-0033		2	TSTR: Si NPN 2N3391	24446	2N3391
A1Q4	1850-0062		1	TSTR: Ge PNP 2N404	01295	GA287 obd
A1Q5	1854-0033			TSTR: Si NPN 2N3391	24446	2N3391
A1Q6	1855-0023		1	TSTR: FET SU527	17856	SU527
A1Q7	1854-0057		4	TSTR: Si 2N3855A	24446	2N3855A
A1Q8	1853-0023		2	TSTR: Si PNP 2N3703	01295	obd
A1Q9	1854-0057			TSTR: Si 2N3855A	24446	2N3855A
A1R1	0757-0198		1	R: fxd prec met flm 100 ohms ±1% 1/2 w	75042	CEC T-O obd
A1R2	0684-5611		1	R: fxd comp 560 ohms ±10% 1/4 w	01121	CB5611
A1R3	0684-1541		1	R: fxd comp 150 K ±10% 1/4 w	01121	CB1541
A1R4	0757-0444		1	R: fxd prec met flm 12.1 K ±1% 1/8 w	75042	CEA T-O obd
A1R5	2100-1735		1	R: var ww 5 ohms ±10% 1-1/2 w	11236	110 obd
A1R6, A1R7	0757-0052		2	R: fxd prec met flm 500 K ±1% 1/2 w	75042	CEC T-O obd
A1R8	0757-0453		1	R: fxd prec met flm 30.1 K ±1% 1/8 w	75042	CEA T-O obd
A1R9	0757-0454		1	R: fxd prec met flm 33.2 K ±1% 1/8 w	75042	CEA T-O obd
A1R10	0698-4199		1	R: fxd prec met flm 2800 ohms ±1% 1/4 w	19701	MF6C T-O obd
A1R11				Not assigned		
A1R12	0757-0439		1	R: fxd prec met flm 6810 ohms ±1% 1/8 w	75042	CEA T-O obd
A1R13	0757-0440		2	R: fxd prec met flm 7500 ohms ±1% 1/8 w	75042	CEA T-O obd
A1R14	0684-3321		1	R: fxd comp 3300 ohms ±10% 1/4 w	01121	CB3321
A1R15	2100-0394		1	R: var ww 300 ohms ±20% 1-1/2 w	71450	110 obd
A1R16	0698-4205		1	R: fxd prec met flm 21 K ±1% 1/8 w	75042	CEA T-O obd
A1R17	0698-4207		1	R: fxd prec met flm 44.2 K ±1% 1/8 w	75042	CEA T-O obd
A1R18	2100-0328		2	R: var ww 500 ohms ±10% 1-1/2 w	71450	110 obd
A1R19	0757-0408		1	R: fxd prec met flm 243 ohms ±1% 1/8 w	75042	CEA T-O obd
A1R20	2100-0205		2	R: var ww 5000 ohms ±10% 1-1/2 w	28480	2100-0205
A1R21	0698-4202		1	R: fxd prec 8870 ohms ±1% 1/8 w	75042	CEA T-O obd
A2	00427-66502		1	Assembly: board AC Metering Circuit includes C1 thru C9 Q1 thru Q3 CR1 thru CR4 R1 thru R17	28480	00427-66502
A2C1	0180-0039		3	C: fxd elect 100 µf 12 vdcw	56289	30D107G012DC4M1
A2C2*	0140-0356		1	C: fxd mica 18 pf ±5% 300 vdcw	04062	obd
A2C3	0130-0017		1	C: var cer 8-50 pf	72982	557-019-U2PO-34R
A2C4	0180-0060		1	C: fxd elect 200 µf +100% -10% 3 vdcw	56289	30D207G003DC4
A2C5	0180-0033		1	C: fxd elect 50 µf +100% -10% 6 vdcw	56289	30D506G006CB4M1

Table 7-1. Replaceable Parts (Cont'd)

REF DESIG	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO.
A2C6	0180-0039			C: fxd elect 100 µf 12 vdcw	56289	30D107G012DC4M1
A2C7, A2C8	0180-0064		2	C: fxd elect 35 µf +100% -10% 6 vdcw	56289	30D356G006BB4
A2C9	0180-0039			C: fxd elect 100 µf 12 vdcw	56289	30D107G012DC4M1
A2CR1	1902-0040		1	Diode: zener 14 v	04713	SZ10939-224
A2CR2				Not assigned		
A2CR3, A2CR4	1910-0022			Diode: Ge HD1872	03877	obd
A2Q1, A2Q2	1854-0057			TSTR: Si 2N3855A	24446	2N3855A
A2Q3	1853-0023			TSTR: Si NPN 2N3703	01295	obd
A2R1	0757-0283		1	R: fxd prec met flm 2000 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R2	0698-4202		1	R: fxd prec met flm 8870 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R3	2100-0328			R: var ww 500 ohms ±10% 1-1/2 w	71450	110 obd
A2R4	2100-0291		1	R: var ww 1500 ohms ±20% 1-1/2 w	71450	110 obd
A2R5	2100-0205			R: var prec ww 5000 ohms ±10% 1-1/2 w	28480	2100-0205
A2R6	0757-0449		1	R: fxd prec met flm 20 K ±1% 1/8 w	75042	CEA T-O obd
A2R7	2100-0094		1	R: var pot comp lin 50 K ±30% 1/10 w	71450	UPE 70RE (hp) obd
A2R8	0757-0465		1	R: fxd prec met flm 100 K ±1% 1/8 w	75042	CEA T-O obd
A2R9	0698-4207		1	R: fxd prec 44.2 K ±1% 1/8 w	75042	CEA T-O obd
A2R10	0757-0461		1	R: fxd prec met flm 68.1 K ±1% 1/8 w	75042	CEA T-O obd
A2R11	0757-0419		1	R: fxd prec met flm 681 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R12	0684-2731		1	R: fxd comp 27 K ±10% 1/4 w	01121	CB2731
A2R13	0757-0437		1	R: fxd prec met flm 4750 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R14	0683-9105		1	R: fxd comp 91 ohms ±5% 1/4 w	01121	CB9105
A2R15	0757-0440			R: fxd prec met flm 7500 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R16	0698-5060		1	R: fxd met flm 53.6 ohms ±1% 1/8 w	75042	CEA T-O obd
A2R17	2100-0239		1	R: var ww 2000 ohms ±20% 1-1/2 w	11236	110 obd
B1	1420-0030		1	Battery: 22-1/2 v dry cell	83740	No. 763 obd
C1, C2	0170-0022		2	C: fxd my 0.1 µf ±20% 600 vdcw	000LH	HEW-17 obd
C3	0132-0003		1	C: var trimmer 0.7 to 3 pf	72982	535-016-4R
C4	0140-0152		1	C: fxd mica 1000 pf ±5% 300 vdcw	04062	DM16F102J
J1				See Option 01		
J2				See MP16 and MP18		
M1	1120-0903		1	Meter: 100 µa	28280	1120-0903
R1	0684-1031		1	R: fxd comp 10 K ±10% 1/4 w	01121	CB1031
R2	0698-4217		1	R: fxd prec carbon flm 6.837 meg ±1% 2 w	91637	DC2 obd
R3	0730-0113		1	R: fxd prec carbon flm 2.163 meg ±1% 1 w	91637	DC1 obd
R4	0698-4214		1	R: fxd prec met flm 683.7 K ±0.5% 1/4 w	75042	CEB T-O obd
R5	0698-4212		1	R: fxd prec met flm 216.3 K ±0.5% 1/4 w	75042	CEB T-O obd
R6	0698-4209		1	R: fxd prec met flm 68.37 K ±0.5% 1/4 w	75042	CEB T-O obd
R7	0698-4206		1	R: fxd prec met flm 21.63 K ±0.5% 1/4 w	75042	CEB T-O obd
R8	0698-4203		1	R: fxd prec met flm 10 K ±0.5% 1/4 w	75042	CEB T-O obd
R9	0684-1051		1	R: fxd comp 1 meg ±10% 1/4 w	01121	CB1051
R10	0698-4128		1	R: fxd prec met flm 10 meg ±0.25% 1/2 w	03888	PME 70 obd
R11	0698-4129		1	R: fxd prec met flm 31.723 K ±0.1% 1/4 w	75042	CEB T-3 obd
R12	0698-4219		1	R: fxd prec carbon flm 11.74 meg ±1% 1 w	91637	DC1 obd
R13	0698-4189		1	R: fxd prec met flm 10.15 ohms ±1% 1/4 w	19701	MF6C T-O obd
R14	0698-4191		1	R: fxd prec met flm 101.5 ohms ±1% 1/4 w	19701	MF5C T-O obd
R15	0698-4198		1	R: fxd prec met flm 1174 ohms ±1% 1/4 w	19701	MF6C T-O obd
R16	0698-4204		1	R: fxd prec met flm 11.75 K ±1% 1/4 w	19701	MF6C T-O obd
R17	0698-4210		1	R: fxd prec met flm 118.8 K ±1% 1/4 w	19701	MF6C T-O obd
R18	0698-4215		1	R: fxd prec met flm 1.295 meg ±1% 1/2 w	75042	CEC obd

Table 7-1. Replaceable Parts (Cont'd)

REF DESIG	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO.	
R19	0698-4220		1	R: fxd prec carbon flm 67.5 meg ±1% 2 w	91637	DC2	obd
R20	0698-4194		1	R: fxd prec met flm 675 ohms ±0.5% 1/4 w	75042	CEB T-O	obd
R21, R22	0698-4201		2	R: fxd prec met flm 6750 ohms ±0.5% 1/4 w	75042	CEB T-O	obd
R23	0698-4208		1	R: fxd prec met flm 67.6 K ±0.5% 1/4 w	75042	CEB T-O	obd
R24	0698-4213		1	R: fxd prec met flm 682 K ±0.5% 1/4 w	75042	CEB T-O	obd
R25	0730-0131		1	R: fxd prec carbon flm 7.5 meg ±1% 1 w	91637	DC-1	obd
R26	0698-4200		1	R: fxd prec met flm 3419 ohms ±0.25% 1/8 w	75042	CEA T-O	obd
R27	0698-4197		1	R: fxd prec met flm 1081 ohms ±0.25% 1/8 w	75042	CEA T-O	obd
R28	0698-4193		1	R: fxd prec met flm 341.9 ohms ±0.25% 1/8 w	75042	CEA T-O	obd
R29	0698-4192		1	R: fxd prec met flm 108.1 ohms ±0.25% 1/8 w	75042	CEA T-O	obd
R30	0698-4190		1	R: fxd prec met flm 50 ohms ±0.25% 1/8 w	75042	CEA T-O	obd
R31	0698-4196		1	R: fxd prec met flm 1070 ohms ±1% 1/8 w	75042	CEA T-O	obd
R32	0757-0418		1	R: fxd prec met flm 619 ohms ±1% 1/8 w	75042	CEA T-O	obd
R33	0757-0442		1	R: fxd prec 909 ohms ±1% 1/8 w	75042	CEA T-O	obd
R34	0698-4195		1	R: fxd prec met flm 1020 ohms ±1% 1/8 w	75042	CEA T-O	obd
R35, R36	0698-4211		2	R: fxd prec met flm 158 K ±1% 1/8 w	75042	CEA T-O	obd
R37	2100-1737		1	R: var ww 200 ohms ±20% DC ZERO/Ω ∞	71450	Type 118	obd
S1	00427-61902		1	Switch: range	28480	00427-61902	
S2	00427-61901		1	Switch: function	28480	00427-61901	
				OPTION 01			
C1	0180-1802		1	C: fxd Al elect 150 μf +100% -10% 40 vdcw	56289	obd	
CR1	1901-0025		1	Diode: Si 100 ma at +1 v 100 piv 12 pf	28480	1901-0025	
J1	1251-1009		1	Connector: ac power cord receptacle	82389	AC-3	obd
S3	3101-0011		1	Switch: slide DPDT LINE/BATT	42190	4603	obd
S4	3101-0033		1	Switch: slide DPDT 115/230	42190	4633	obd
T1	9100-1328		1	Transformer: ac power	28480	9100-1328	
				MECHANICAL PARTS SEE FIGURE 7-1			
MP1	5060-0708		1	Cover: top	28480	5060-0708	
MP2	5060-0702		2	Assembly: frame 6 x 8 sm	28480	5060-0702	
MP3	00427-00203		1	Panel: rear (Option 01 only)	28480	00427-00203	
MP3	00427-00202		1	Panel: rear	28480	00427-00202	
MP4	5000-0702		2	Cover: side 6 x 8 sm	28480	5000-0702	
MP5	5060-0727		2	Assembly: foot third module	28480	5060-0727	
MP6	5040-0700		2	Hinge	28480	5040-0700	
MP7	1490-0031		1	Stand: tilt third module stainless steel rod	91260	obd	
MP8	5000-0710		1	Cover: bottom 5 x 8 sm	28480	5000-0710	
MP9	00427-00201		1	Panel: front	28480	00427-00201	

Table 7-1. Replaceable Parts (Cont'd)

REF DESIG	-hp- PART NO.		TQ	DESCRIPTION	MFR	MFR PART NO.
MP10	5020-0704		1	Meter trim: third module	28480	5020-0704
MP11	0370-0311		1	Thumbwheel: DC ZERO/Ω ∞	28480	0370-0311
MP12	00427-01201		1	Bracket: DC ZERO/Ω ∞ adjust	28480	00427-01201
MP13	1750A-64A		1	Holder: trimmer capacitor (used with C3)	28480	1750A-64A
MP14	00427-00601		1	Shield: switch	28480	00427-00601
MP15	00427-05501		1	Shield: can (Option 01 only)	28480	00427-05501
MP16	1510-0009		1	Assembly: binding post black COM w/o solder turret brass, P/O J2	28480	1510-0009
MP17	0340-0099		3	Insulator: binding post single grey plastic 0. 500" OD x 0. 200" ID x 0. 090" thick with anti-rotation boss, P/O J2	28480	0340-0099
MP18	1510-0008		2	Assembly: binding post VOLTS red w/o solder turret brass, P/O J2 Assembly: binding post OHMS red w/o solder turret brass, P/O J2	28480	1510-0008
MP19	0370-0077		2	Knob: skirted bar 5/8" diameter black for 1/4" diameter shaft	28480	0370-0077
MP20	00427-06401		1	Holder: battery	28480	00427-06401
MP21	00427-90000		1	Manual: operating and service	28480	00427-90000

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c o Electrical Spec Co.)	Cleveland, Ohio
05624	Barber Colman Co	Rockford, Ill.
05728	Tiffen Optical Co. Roslyn Heights	Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc	Wakefield, Mass
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y
06402	E T A Products Co. of America	Chicago, Ill
[illegible]	Western Devices Inc	Inglewood, Calif
06540	Amatom Electronic Hardware Co Inc	New Rochelle, N Y
06555	Beede Electrical Instrument Co., Inc.	Penacook N H
06751	U S Semcor Division of Nuclear Corp of America	Phoenix, Arizona
[illegible]	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co	Van Nuys Calif
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J
24446	General Electric Co	Schenectady N Y
24455	G.E., Lamp Division Nela Park	Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc	San Bruno, Calif
72136	Electro Motive Mfg. Co., Inc	Willimantic Conn
71707	Coto Coil Co., Inc.	Providence, R.I
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y
72656	General Ceramics Corp.	Keasbey, N.J
72699	General Instrument Corp., Semiconductor Div	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co	Chicago, Ill
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp	Erie, Pa.
73061	Hansen Mfg. Co., Inc	Princeton Ind.
73076	H.M. Harper Co	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N Y
80031	Mepco Division of Sessions Clock Co	Morristown N.J
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn
80223	United Transformer Corp.	New York, N.Y
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif
80411	Acro Div. of Robertshaw Fulton Controls Co	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif
80583	Hammerlund Co., Inc.	New York, N Y
80640	Stevens, Arnold, Co., Inc.	Boston Mass
81030	International Instruments, Inc	New Haven
81073	Grayhill Co.	LaGrange, Ill
81095	Triad Transformer Corp.	Venice, Calif
81312	Winchester Electronics Co., Inc.	Norwalk Conn

Galley 3 – Hewlett Packard Code List

From FSC Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
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95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

Code No.	Manufacturer	Address
J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

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